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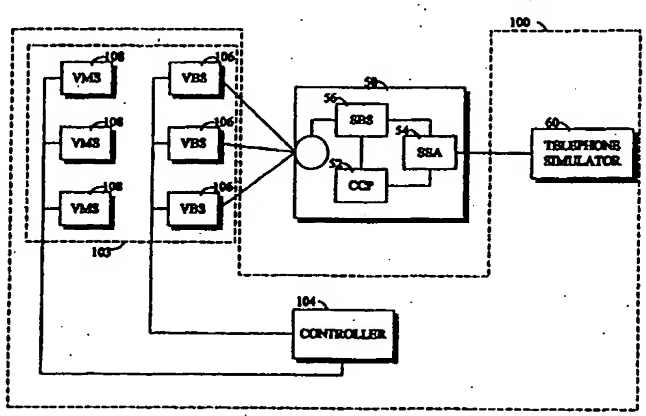

(57) Abstract

A test system and method used in testing a mobile communications network (100) infrastructure. The test system includes a test controller (104), a virtual call manipulator (103), and a telephone simulator (60). The test controller (104) outputs a command signal determining a type of test to be performed. The virtual call manipulator (103) is coupled to the test controller (104). The virtual call manipulator (103) responds to the command signal and to base station controller (50) signals from a base station controller (50) under test to provide base station test signals. The base station test signals correspond to the test type and are comparable to actual base station signals that would be generated by an actual base station. The virtual call manipulator (103) inputs the base station test signals to said base station controller (50) under test. The telephone simulator (60) is coupled to the test controller and is responsive to the command signal and said base station controller signals to provide test telephone signals. The test telephone signals correspond to the test type and are comparable to actual telephone signals. The test telephone signals are input to the base station controller under test. The invention should be particularly useful in testing base station controllers in CDMA cellular telephone networks.

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TEST SYSTEM AND METHOD USED IN TESTING A MOBILE COMMUNICATIONS NETWORK INFRASTRUCTURE

BACKGROUND OF THE INVENTION

I. Field of the Invention

This invention relates generally to wireless communication networks such as, for example, cellular wireless telephone systems and personal communication systems. More specifically, this invention relates to a novel and improved system and method for testing communications networks.

II. Related Art

The use of code division multiple access (CDMA) modulation techniques is one of several methods for facilitating communications in systems accommodating a large number of users. Other multiple access communication system techniques, such as time division multiple access (TDMA), frequency division multiple access (FDMA) and AM modulation schemes such as amplitude companded single sideband are known in the art. However, CDMA spread spectrum modulation techniques have significant advantages over other modulation techniques for multiple access communication systems. The use of CDMA techniques in a multiple access communication system is disclosed in U.S. Pat. No. 4,901,307, which issued February 13, 1990, entitled "SPREAD SPECTRUM MULTIPLE ACCESS COMMUNICATION SYSTEM USING SATELLITE OR TERRESTRIAL REPEATERS", and is assigned to the assignee of the present invention, and is incorporated by reference herein in its entirety.

In U.S. Pat. No. 4,901,307, referred to above, a multiple access technique is disclosed where a large number of wireless system users each having a transceiver communicate through satellite repeaters or terrestrial base station transceivers using CDMA spread spectrum communication signals. In using CDMA communications techniques, the frequency spectrum can be reused multiple times thus permitting an increase in system user capacity. The use of CDMA techniques results in a much higher

spectral efficiency than can be achieved using other multiple access techniques.

To determine the behavior of the CDMA system under high call volumes, a selected number of subscriber units may be deployed at various distances as a way of generating large amounts of call traffic. Attempting this through field testing requires a full ensemble of subscriber units and deployed cell sites. This presents a logistical problem and is not economically feasible. What is needed is a way of testing the CDMA infrastructure before deployment of the entire CDMA system.

SUMMARY OF THE INVENTION

The invention features a test system and method used in testing a mobile communications network infrastructure. The test system includes a test controller, a virtual call manipulator, and a telephone simulator. The test controller outputs a command signal determining a type of test to be performed. The virtual call manipulator is coupled to the test controller. The virtual call manipulator responds to the command signal and to base station controller signals from a base station controller under test to provide base station test signals. The base station test signals correspond to the test type and are comparable to actual base station signals that would be generated by an actual base station. The virtual call manipulator inputs the base station test signals to said base station controller under test. The telephone simulator is coupled to the test controller and is responsive to the command signal and said base station controller signals to provide test telephone signals. The test telephone signals correspond to the test type and are comparable to actual telephone signals. The test telephone signals are input to the base station controller under test.

In some embodiments, the virtual call manipulator includes a virtual base station and a virtual mobile station. The virtual base station provides the base station test signals. The virtual mobile station is responsive to the command signal and to the base station test signals to provide mobile station test signals. The mobile station test signals correspond to the test type and

are comparable to actual mobile station signals that would be generated by an actual mobile station. The virtual base station interfaces the virtual mobile station with the base station controller under test by accepting the mobile station test signals, the command signal, and the base station controller signals to provide the base station test signals.

In some embodiments, the simulator includes a telephone simulator coupled to the test controller. The telephone simulator is responsive to the command signal and the base station controller signals to provide test telephone signals. The test telephone signals correspond to the test type and are comparable to actual telephone signals and are input to the base station controller under test.

An invention method of testing a communications network by simulating a call includes simulating a call and outputting information regarding the call. The call is between a virtual call manipulator and a telephone number via a base station controller under test.

Because of the large number of calls required to fully test the communications network, it is impractical to use large numbers of actual mobile stations and actual base stations to test the communications network. The invention has an advantage over conventional techniques of permitting testing of the mobile communication network at or above its capacity without the need for actual mobile stations and actual base stations.

The invention should be particularly useful in testing of CDMA networks. In particular, the invention can test a base station controller which would be used in a CDMA network as a part of high level network design. Such testing typically would occur before the base station controller is in the CDMA network and the actual base and mobile stations are deployed but after the base station controller's protocols have been tested for low call volumes. This high level network design testing verifies expected behavior of the base station controller.

These and other objects, features, and advantages of the invention will become readily apparent to those skilled the art upon a study of the following drawings and a reading of the description of the invention below.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram of an embodiment of a mobile air link test system (MALTS) testing a communications network in accordance with the present invention.

Figure 2 is a block diagram of an embodiment of a MALTS hardware environment in accordance with the present invention.

Figure 3 is a block diagram of an embodiment of a MALTS in accordance with the present invention.

Figure 4 is a diagrammatic representation of a MALTS user interface in accordance with the present invention.

Figure 5 is a flowchart illustrating a method of testing a communications network by simulating a call.

Figure 6 is a flowchart illustrating Step 504 of configuring the base station controller described with reference to **Figure 5** in greater detail.

Figure 7 is a flow chart illustrating Step 506 of running simulator subsystems described above with reference to **Figure 5** in greater detail.

Figure 8 is a flow chart illustrating setting up a call as would occur during Step 706 of simulating call loads described above with reference to **Figure 7**.

Figure 9 is a flow chart illustrating setting up a call between two virtual mobile stations as may be performed in Step 706 of simulating call loads described above with reference to **Figure 7**.

Figure 10 is a flow chart illustrating a step of a virtual mobile station initiated tear down 1000 of a call as would occur during Step 706 of simulating call loads described above with reference to **Figure 7**.

Figure 11 is a flow chart of a telephone simulator initiated teardown as would occur during Step 706 of simulating call loads described above with reference to **Figure 7**.

Figures 12A-D are flowcharts illustrating soft and softer handoff adds and drops as would occur during Step 706 of simulating call loads described above with reference to **Figure 7**.

Figure 13 is a flow chart illustrating Step 508 of outputting test data described above with reference to **Figure 5**.

Figure 14 illustrates a detailed sequence of commands for a call setup for a call originated by a virtual mobile station associated with setting up 800 of **Figure 8**.

Figure 15 illustrates a detailed sequence of commands for a call setup for a call terminating on the virtual mobile station associated with setting up 800 of **Figure 8**.

Figure 16 illustrates a detailed sequence of commands to release a call originated by the virtual mobile station associated with the teardown 1000 of **Figure 10**.

Figure 17 illustrates a detailed sequence of commands to release a call terminating on the virtual mobile station associated with the teardown 1100 of **Figure 11**.

Figure 18 illustrates a detailed sequence of commands for a soft handoff setup and end associated with the method of **Figure 12A**.

Figure 19 illustrates a detailed sequence of commands for a softer handoff setup and end associated with the method of **Figure 12B**.

Figure 20 is a computer which may host the controller, virtual base station, and/or virtual mobile station in some embodiments of the invention.

DESCRIPTION OF THE INVENTION

The invention features a test system and method used in testing a mobile communications network infrastructure. The test system includes a test controller, a virtual call manipulator, and a telephone simulator. In some embodiments, the virtual call manipulator includes a virtual base station and a virtual mobile station. The virtual base station provides the base station test signals. The tests the communications network by simulating a call between a virtual call manipulator and a telephone number via a base station controller under test and outputting information

regarding the call. Some embodiments of the test system will be referred to below as a mobile air link test system (MALTS).

The invention has an advantage over conventional techniques of permitting testing of the mobile communications network at or above its capacity. Previously, such testing was not feasible because conventional techniques required large numbers of actual mobile stations and actual base stations. The invention obviates these requirements.

For background material, the reader is directed to the following standard textbooks and standards publications all of which are incorporated by reference herein in their entirety: *Electrical Engineering Handbook*, edited by Richard C. Dorf, CRC Press, 1993; *Cellular Radio Systems*, D.M. Balston and R.C.V. Macario (eds.), Artech House, 1993; *Telecommunications Primer: Signals, Building Blocks and Networks*, E. Bryan Carne, Prentice Hall, 1995; *CDMA For Wireless Personal Communications*, Ramjee Prasad, Artech House, 1996; *Wireless Communications Principles & Practice*, Theodore S. Rappaport, Prentice Hall, 1996; *CDMA Principles of Spread Spectrum Communications*, Andrew J. Viterbi, Addison-Wesley, 1996; *IS-95-A Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System*, Telecommunications Industry Association, 1995; *PN-3570/TSB-74: Support for 14.4 kbps Data Rate and PCS Interaction for Wideband Spreads Spectrum Cellular System*, Telecommunications Industry Association, 1995; *MC68040 MC68EC040 MC68LC040 Microprocessor User's Manual*, Motorola, Inc., M68040UM/AD, 1992; *MC68000 Family Reference*, Motorola, Inc., M68000FR/AD, 1990.

Several operations or steps are described below as performed on a "computer." Those skilled in the art will appreciate that although it may be convenient to perform multiple steps on one processor or central processing unit (C.P.U.), the invention does not require it. Indeed, it may be advantageous to perform some steps on one processor or C.P.U. and other steps on one or more other processors or C.P.U.'s. Therefore, the term computer should be construed to include multiple processors and C.P.U.'s which may be electrically or electromagnetically coupled via one or more networks as well as those not connected as in multiple stand alone

machines. Of course, data can be transferred between stand alone machines by various machine readable media such floppy disks, tapes, CD-ROMS, hard drives, etc.

Although the following description will focus on applications of the invention to testing mobile cellular networks and base station controllers in particular, it is anticipated that the invention will be applicable to testing other communications networks.

Figure 1 is a diagrammatic representation of a mobile air link test system (MALTS) 100 of the invention configured to test a base station controller 50 of a CDMA communications network. The base station controller includes a call control processor (CCP) 52, a switch services adjunct (SSA) 54, and a selector bank subsystem (SBS) 56. The Rappaport and Balston et al. references cited above discuss how the base station controller 50 functions within the CDMA communications network.

The base station controller 50 is coupled to a telephone simulator 60. The telephone simulator 60 is any software or hardware capable of generating and receiving telephone signals mimicking signals that would be transferred between an actual telephone network and the CDMA communications network. In some embodiments, the testing requirements of the telephone simulator 60 may be fulfilled by a standard central office simulator.

The CCP 52 controls call switching functions for the CDMA communications network. The functions may include three-way calling, caller identification, messaging, and other functions as are typical in modern telephone and communications systems. The SSA allows the CCP 52 to communicate with the CDMA on the BSC 50. Calls between the telephone simulator 60 and the cellular network are coupled to the CCP 52 via the SSA 54.

The SBS 56 is a bank of selectors. Each selector in the bank selects a cell in the CDMA network which handles a particular call. This is useful since a single call to a mobile station, such as a cellular telephone, may be in communication with more than one cell site or base station. Since one cell may have a better signal than another at a particular time during the call, the

selectors in the SBS 56 select the cell to be used for the call at that particular time.

In an actual CDMA, the SBS 56 is coupled to various actual base stations which send and receive messages to and from an actual mobile station, e.g. a cellular telephone. To permit full loading and testing of the CDMA system, the MALTS 100 includes a virtual call manipulator 103.

The virtual call manipulator 103 mimics functionality and loads of actual base stations (cell sites) and actual mobile stations (cellular phones) in communication with the base station controller 50 under test. The virtual call manipulator 103 accepts signals from the base station controller 50 and responds to these signals with virtual base station test signals comparable to actual base station signals that would be produced by an actual base station in response to the signals from the base station controller 50. The virtual call manipulator 103 is also capable of generating virtual base station test signals and inputting the signals to the base station controller 50 without first receiving signals from the base station controller 50.

In some embodiments, the virtual call manipulator 103 includes virtual base stations 106 and virtual mobile stations 108 instead of actual base stations and actual mobile stations. The virtual base stations 106 and virtual mobile stations 108 provide inputs and responses to the base station controller 50 for a range of operating conditions specified by a user of the MALTS 100 to test the base station controller 50 and its components. A controller 104 for the MALTS 100 is coupled to the virtual base stations 106 and virtual mobile stations 108 and hence the virtual call manipulator 103.

Embodiments of the MALTS invention 100 may be in hardware, software, or combinations of hardware and software. For example, in embodiments including software, the virtual call manipulator 103, the virtual base stations 106, and the virtual mobile stations 108 may be software modules on a computer that respond to the manager 102 , the controller 104, and the base station controller 50 in the manner described.

Figure 2 illustrates an embodiment of a hardware arrangement for the MALTS 100 in accordance with the invention. The MALTS manager 102 runs on a computer 200 connected to a monitor 202 and a hard drive 204.

The computer 200 is also connected to, or contains, a keyboard 206 to permit a user to input commands to the computer 200 to control the MALTS simulation. In the hardware arrangement shown in **Figure 2**, the controller 104, the virtual base station 106 and the virtual mobile station 108 are on selector bank subsystem type cards, the same type of hardware that can be used for the selector bank subsystem 56. However, the SBS 56 is not required to be on the selector bank subsystem type cards as the virtual base stations 106 and the virtual mobile stations 108. These cards selector bank subsystem type cards hosting the virtual base stations 106 and the virtual mobile stations 108 are connected to the computer 200. In some embodiments the selector bank subsystem type cards are connected to the computer 200 via a base station communications network (BCN). In other embodiments, the selector bank subsystem cards are connected to the computer 200 via an ethernet connection.

The MALTS manager running on the computer 200 may receive input instructions via the keyboard 206 or via a command script. As illustrated in **Figure 2**, the command script may be received from a system test metacontroller 208 which is part of a computer 210. In some embodiments the computer 210 will also be connected to a monitor 212 and a keyboard 214. The system test metacontroller (STMC) 208 and the computer 210 are connected to the computer 200. In **Figure 2**, the connection may be provided by an ethernet connection although other connection protocols may be used. The hard drive 204 is connected to the computer 200. In the embodiment shown in **Figure 2**, the connection may be provided via an ethernet although other protocols may be used.

Figure 3 shows a software environment for the MALTS 100. The MALTS manager 102 receives commands from either the STMC 208, a user 300, or both. The MALTS manager 102 communicates with the MALTS controller 104, the virtual base station 106, and the virtual mobile station 108 via commands in the network operation interface specification (NOIS) on an applications communications network (ACN). The MALTS manager 102 is coupled to a memory such as the hard drive 204 via a network file system (NFS).

The controller 104 outputs a command signal determining a type of test to be simulated by the MALTS 100. The virtual base station 106 is coupled to the controller and responsive to the command signal. The virtual base station 106 regenerates base station test data comparable to actual base station data that would be generated by an actual base station. Similarly, the virtual mobile station 108 is coupled to the controller and responsive to the command signal. The virtual mobile station 108 regenerates mobile station test data comparable to actual mobile station data that would be generated by an actual mobile station. The manager 102 receives an input command from a command source such as the STMC 208 or the user 300. The manager 102 sends a system command to the controller 104 based on the input command. The system command at least partially determines the type of test to be simulated by the MALTS 100.

The user 300 is free to define how comparable the generated data is to the actual data. For example, in some embodiments, the generated data may be approximately equal, for a specified tolerance, to actual data for subsets of parameters output over a range of values or at discrete points. In some embodiments, the generated data may be essentially identical to the actual data. In some embodiments, the generated data will not approximate or equal the actual data, but the generated data will invoke responses from components in the base station controller 50 that would be invoked by the actual data.

The manager 102 starts the controller 104 by sending a start signal to the controller 104. If the controller 104 has not already begun processing, the manager 102 also initializes the controller. The manager may also reinitialize the controller 104 after the controller 104 has started. Similarly, the manager 102 initializes the virtual base station 106 by sending a base station initialization command to the virtual base station 106, and the manager 102 initializes the virtual mobile station 108 by sending a mobile station initialization command to the virtual mobile station 108.

As noted above the manager 102 receives command signals from command sources. To set up the simulation performed by the MALTS 100, the manager 102 relays simulation parameters received from the command

sources to the controller 104. Before sending the simulation parameters to the controller 104, the manager 102 may first store the simulation parameters in memory such as the hard drive 204. In some embodiments, system commands output by the manager 102 may be identical to the input command signals received from the command sources. This might be the case, for example, when the components of the MALTS 100 utilize the same computer language or network protocol utilized by the command sources or networks connected to the command sources.

The manager 102 may also coordinate storage and retrieval of other inputs and outputs of the MALTS simulation 100. In particular, the manager 102 may store logging information regarding the simulation in memory 204.

In some embodiments, the controller 104 includes a memory with which the controller 104 maintains a database of information about the virtual base station 106 and the virtual mobile station 108. The controller 104 does this by sending signals to and receiving signals from the virtual mobile station 108 and the virtual base station 106. The information maintained may include ACN network addresses, simulated physical locations, lists of links between the virtual base station 106 and the virtual mobile station 108, call status, handoff status among cell sites, lists of neighboring cell sites or sectors for each cell site, calculated pilot signal strength, and IS-95A information.

ACN addresses are a way of directing messages between the different applications in the system such as the PAM. The simulated physical locations are the virtual sectors associated with virtual base stations 108 in which the virtual mobile stations 106 move. The list of links are internal ACN addresses used by the MALTS 100. Call status refers to a possible states in which the VMS 108 can be in such as idle, setup, connected, or teardown. Handoff status is similar to call status in that it describes a possible call state. However, hand-off status can refer to 2-way and 3-way handoff between virtual base stations 106 between which a call is transferred. The lists of neighboring cell sites is a list of potential sites that a call can be handed-off to. The pilot signal strength determines whether a handoff is advantageous to

the call to continue. Each cell is configured to provide information to a virtual mobile station 108 that is active.

Additionally, input parameters and input system commands may be stored by the controller 104 in its memory. The controller 104 may also, in some embodiments, store overhead channel information in the memory and update the channel information stored in the memory when the channel information changes.

Essentially, the controller 104 supervises the creation, the simulation, and the destruction, of simulated calls between the telephone simulator 60 and the virtual call manipulator 103 which test the cellular communications network. The controller 104 controls handoffs amongst virtual base stations 106 which communicate with the virtual mobile station 108. The controller 104 also logs call statistics, handoff statistics, and fault data. These statistics and fault data may be stored in memory or output via the manager 102.

Figure 4 illustrates a MALTS user interface 400. The exemplary user interface shown in **Figure 4** could be displayed on the monitor 202 or the monitor 212 illustrated in **Figure 2**. The user interface 400 can be used by a user 300 to interactively control the MALTS 100. The MALTS user interface 400 has a menu bar 410, a command line 430, a current status area 440 and a cumulative status area 450. It is emphasized that the following menus and options may be used in some embodiments of the invention but are not required by all embodiments of the invention.

The menu bar 410 has five pull down buttons: a control button 412, a parameters button 414, a configure button 416, a clear button 418, and a help button 419. The control button 412 brings up options for the overall control of the MALTS 100. These options include starting the simulation and resetting the rest of the MALTS 100, for example. The parameters button 414 provides options for setting parameters related to calls and parameters useful to the interface 400. The configure button 416 provides options for configuring the virtual base stations 106 and permits adding virtual mobile stations 108 and telephone numbers in the telephone simulator 60 to the MALTS simulation. In so doing, the added virtual base stations 106, virtual mobile stations 108, and telephone numbers are usable in call simulations.

Enough virtual base stations 106, virtual mobile stations 108, and telephone numbers must be added to simulate high call volumes as might occur in an actual deployment. The clear button 418 permits the user 300 to clear the output window 430. The help button 419 lists command line commands and instructions for using them.

A series of flowcharts will now be presented illustrating an embodiment of a testing method of the invention. Because of the complexity of the testing environment, these flowcharts are meant to be illustrative only.

Figure 5 is a flowchart illustrating a method 500 of testing a communications network by simulating a call beginning at a step 502. Communication protocols have been previously tested for one or a small number of calls during development and are assumed to work for very large numbers of calls. Thus, the method 500 tests whether the base station controller 50 works under high-call volumes.

Step 504 configures or sets up the base station controller (BSC) 50 to recognize the various virtual base stations (VBS's) 106. Step 506 runs the various simulator subsystems such as the virtual base stations 106, the virtual mobile stations 108, and the telephone simulator 60. Step 508 outputs test data resulting from testing the communications network infrastructure, and Step 510 ends the method 500.

Figure 6 is a flowchart illustrating Step 504 of configuring the BSC 50 described with reference to **Figure 5** in greater detail. Step 504 begins at Step 600, and Step 602 recognizes the virtual base stations 106. Step 602 includes determining system parameters for each virtual base station 106 just as they would be for actual base stations. Base station system parameters typically include latitudinal and longitudinal coordinates of the base station (cell site), data addresses, and other characteristics of the particular base station.

Step 604 provisions a home location register (HLR) which is part of the BSC 50. The HLR is a data base containing information about calling features paid for by subscribers and an electronic serial number (ESN) associated with each telephone number in the communications network.

For example, the HLR can log whether bills have been paid for a particular phone number and whether a phone number has call waiting, call forwarding, voice mail, etc. Step 504 ends at a Step 606.

Figure 7 is a flow chart illustrating Step 506 described above with reference to **Figure 5** in greater detail beginning at a Step 700. Step 702 receives a script containing global test instructions. For example, the script can state how many calls are to be performed and their duration. The script may also include call statistics and may determine how many virtual base stations 106 and virtual mobile stations 108 are used at any particular time. Those skilled in the art will appreciate that very many sets of global test instructions may be constructed.

Step 704 reads the script. Depending upon the embodiment, either the controller 104, the manager 102, or the system test metacontroller 208 may read the script. Step 706 simulates call loads specified by the script. Step 706 includes setting up and tearing down calls as well as handing off calls between virtual base stations 106. Step 506 ends at a Step 708.

Figure 8 is a flow chart illustrating setting up 800 a call as would occur during Step 706 beginning at a Step 802. The steps illustrated for the embodiment of setting up 800 are performed both when the call is terminated on a virtual mobile station 108 or originated by the virtual mobile station 108. Some of the steps below may be permuted depending upon whether the call is originated or terminated by the selected virtual mobile station 108. In Step 804 the BSC 50 and the telephone simulator 60 perform a handshake. When the telephone simulator 60 includes a central office simulator, the handshake is performed between the BSC 50 and the central office simulator. In Step 806 the MALTS controller 104 sends a set up command to a selected virtual mobile station 108. This virtual mobile station 108 will either receive or send the call. In Step 808 the selected virtual mobile station 108 and a selected virtual base station perform a handshake. Step 808 mimics what actually occurs between an actual mobile station and an actual base station (cell site). In Step 810 the selected virtual base station and the base station controller 50 perform a handshake as would

be performed between an actual base station and the base station controller 50. Step 800 of setting up the call ends at Step 812.

Figure 9 is a flow chart illustrating setting up a call between two virtual mobile stations 108 as may be performed in Step 706 of simulating call loads beginning at a Step 902. In Step 904, the MALTS controller 104 sends a set up command to a selected virtual mobile station 108. In Step 906 the selected virtual mobile station 108 and a selected virtual base station 106 perform a handshake as in Step 808. In Step 908 the selected virtual base station 106 and a second virtual mobile station 108 perform a handshake. The second virtual mobile station 108 notifies the MALTS controller 104 of an incoming call in Step 910. Step 910 prevents the MALTS controller 104 from assigning another call to the second virtual mobile station 108. In Step 912 the MALTS controller 104 sends a receive command to the second virtual mobile station 108. The step of setting up 900 a call between two virtual mobile stations 108 ends in Step 914.

Figure 10 is a flow chart illustrating a step of a virtual mobile station initiated tear down 1000 of a call as would occur during Step 706 of simulating call loads beginning at a Step 1002. In Step 1004 the MALTS controller 1004 sends a release command to a virtual mobile station 108 engaged in the call. The virtual mobile station 108 engaged in the call sends a release order to the base station controller 50 in Step 1006. Unlike an actual tear down, the virtual mobile station 108 sends its release order directly to the base station controller 50 without a required transmission through a virtual base station 106. In Step 1008 the base station controller 50 tears down the call, and Step 1000 ends at a Step 1010.

Figure 11 is a flow chart of a telephone simulator initiated teardown as would occur during Step 706 of simulating call loads. Step 1100 begins at a Step 1102. When the telephone simulator 60 includes the central office simulator, the central office simulator initiates the teardown period. In that case, the central office simulator sends a release command to the base station controller 50 in Step 1104. In Step 1106, the base station controller 50 sends a release order to a virtual mobile station 108 which is engaged in the call. Unlike an actual teardown, the base station controller 50 sends the release

order directly to the virtual mobile station 108 in Step 1106 instead of via the virtual base station 106. In Step 1108, the virtual mobile station 108 engaged in the call acknowledges the release order by sending a signal back to the base station controller 50. In Step 1110, the base station controller 50 tears down the call. Step 1100 ends at a Step 1112.

Under analog cellular telephony, all handoffs are termed as "hard." A mobile station must drop one connection, re-tune, and pick up a new connection whenever it hands off from one cell to another. This connection is termed "break-before-make." Thus, it has some reliability problems since it's possible to lose the connection on the process of going from one frequency to another. Hard handoff is not the preferred type of handoff used in the IS-95 standard, but it does get used when a mobile is asked to move from one frequency overlay to another.

In the IS-95 standard, due to the use of a common frequency for multiple voice channels, a preferred type of handoff is "soft handoff." In this procedure, mobile stations can communicate with the BSC 50 over several different base stations (cells) at the same time. This allows a new base station (cell) to be added to a collection of links before an old one is dropped. This is termed "make-before-break." This scheme is much more reliable because the new link is added before the old link is released.

Due to the nature of the soft handoff scheme, handoff is typically broken into two parts. The first part is "soft handoff add" where a new link is added to the collection of links that a mobile is using. The second part is "soft hand drop" where a link is removed from the collection. These two parts can occur at a widely separated points in time. Given this, they can be considered independently.

In addition, there are generally two variations of soft handoff. One goes by the name "soft" and is used when the combining of the separate channels occur at the BSC 50. The other variant is called "softer" and occurs when the combining occurs at the base station. Another way to think of this is that "soft" hand off occurs when more than one base station (or virtual base station 108 in MALTS 100) is involved. Softer handoff occurs when only one base station (or virtual base station 108 in MALTS 100) is involved.

In a typical CDMA network, there can be up to six links between a mobile station (e.g. cellular telephone) and the BSC 50 at any given time. These six links can be all "soft," all "softer" or some combination of soft and softer handoff. A mobile station that is in contract via two links is said to be in a "2-way handoff," three links is "3-way handoff," etc.

A MALTS 100 simulation of the soft and softer handoffs will now be discussed with reference to **Figures 12A-D.** **Figure 12A** is a flow chart illustrating a soft handoff add 1200 between virtual base stations 108 as would occur during step 706 of simulating call loads beginning at a step 1202. In Step 1204, the controller 104 sends a pilot strength change command to a virtual mobile station 106 initially engaged in a call. In Step 1206 the virtual mobile station creates a pilot signal strength message and sends it to the base station controller 50. The base station controller 50 sends a resource request to a virtual base station 108 which is not initially engaged in the call in Step 1208. In Step 1210 the base station controller 50 sets up an additional link to the virtual mobile station 106, and forward traffic begins through the second virtual base station 108 in Step 1210. In Step 1212, the base station controller 50 sends a handoff direction message to the virtual mobile station 106 indicating that the second virtual base station 108 is now engaged in the call. In Step 1214 the virtual mobile station 106 sends a handoff completion message to the base station controller 50 and notifies the controller 104 of an additional link. Reverse traffic then begins. The soft handoff add 1200 ends at a Step 1212.

Figure 12B is a flow chart illustrating a soft hand off drop 1225 involving a base station initially engaged in the call that was added in the soft hand off add 1200. The soft handoff drop 1225 would occur during Step 706 of simulating call loads and begins at a Step 1226. In Step 1228 the controller 104 sends a pilot strength change command to the virtual mobile station 106. In Step 1230 the virtual mobile station 106 creates a pilot signal strength message and sends it to the base station controller 50. The base station controller 50 sends a handoff direction message to the virtual mobile station 106 in Step 1232. In Step 1234 the virtual mobile station 106 sends a handoff completion message to the base station controller 50 and indicates

an end of handoff to the controller 104. Reverse traffic then ends. In Step 1236 the base station controller 50 disconnects the additional link with the virtual mobile station 106, and forward traffic ends. The base station controller 50 deallocates resources on the virtual base station 108 in Step 1238, and the soft hand off drop 1225 ends in a Step 1240.

Figure 12C is a flow chart illustrating a softer handoff add 1250 as would occur during a Step 706 of simulating call loads beginning at a Step 1252. In Step 1254 the controller 104 sends a pilot strength change command to the virtual mobile station 106. In Step 1256 the virtual mobile station 106 creates a pilot signal strength message and sends it to the base station controller 50. The base station controller 50 sends a resource request to a virtual base station 108 which is initially engaged in the call in Step 1258. In Step 1260 the base station controller 50 sets up an additional link to the virtual mobile station 106, and forward traffic begins. In Step 1262 the base station controller 50 sends a handoff direction message to the virtual mobile station 106 indicating which virtual base station as just been activated. In Step 1264 the virtual mobile station 106 sends a handoff completion message to the base station controller 50 and notifies the controller 104 of an additional link. Reverse traffic then begins. The softer handoff add 1250 ends in a Step 1266.

Figure 12D is a flow chart illustrating a softer handoff drop 1275 as would occur during a Step 706 of simulating call loads beginning at Step 1276. In Step 1278 the controller 104 sends a pilot strength change command to the virtual mobile station 106 engaged in the call. In Step 1280 the virtual mobile station 106 creates a pilot signal strength message and sends it to the base station controller 50. In Step 1282 the base station controller 50 sends a handoff direction message indicating which virtual base station is to remain connected to the virtual mobile station 106 which is engaged in the call. In Step 1284 the virtual mobile station 106 sends a hand off completion message to the base station controller 50 and indicates an end of handoff to the controller 104. The base station controller 50 disconnects the additional link with the virtual mobile station 106 in Step 1286, and the

base station controller deallocates resources on the virtual base station 108 being dropped call in Step 1288. The softer handoff drop ends at a step 1290.

Figure 13 is a flow chart illustrating Step 508 of outputting test data described above with reference to **Figure 5** in greater detail beginning at a Step 1300. Step 1302 outputs call statistics. In some embodiments, the MALTS manager 102 outputs the statistics via the user interface 400 described above with reference to **Figure 4**. Step 1304 outputs functionality data from components of the BSC 50. In some embodiments, each major components of the BSC 50 will have its own RAM which logs data about its performance during testing, and a base station manager accesses the RAM's. For example, the SBS 56 may log numbers of calls made, number call failures, reasons for call failures, or simply a message indicating no failures occurred during testing. Step 508 ends at Step 1306.

Message flow amongst various components of the MALTS 100 will now be described for particular test operations. Message traffic between the virtual base station 106 and the controller 104 is also shown to provide some context for the message flow. Although associated with flowcharts described above, the order of the steps in the flowcharts may not correspond precisely with the sequence of commands below.

Figure 14 illustrates a detailed sequence of commands for a call setup for a call originated by a virtual mobile station 108 associated with the setting up 800 of **Figure 8**. The controller 104 initiates a call request for a virtual mobile station 108. Then, the virtual mobile station 108 sends an origination message to the virtual base station 106 to originate a call. The virtual base station 106 forwards an origination indication to the BSC 50 (CCP 52). The BSC 50 (SBS 56) sends an allocate resource request for a traffic channel on the virtual base station 106 to the virtual base station 106. The virtual base station 106 sends a response to the allocate resource request to the BSC 50. The BSC 50 then sends a traffic channel connect request to the virtual mobile station 108. The virtual mobile station 108 sends a response to the traffic channel connect request back to the BSC 50. The BSC 50 begins sending null traffic to the traffic channel element in the virtual mobile station 108. The BSC 50 (CCP 52) assigns a channel assignment message to

the virtual base station 106. The virtual base station 106 echoes this channel assignment to the virtual mobile station 108. A traffic channel element of the virtual mobile station 108 begins sending null traffic to the BSC 50 (SBS 56). The BSC 50 (SBS 56) sends a base station acknowledgement to the virtual mobile station 108 . The BSC 50 (SBS 56) sends a service option response message to the virtual mobile station 108.

When the BSC 50 (CCP 52) receives an alert indication from the telephone simulator 60, it sends an alert with information message to the virtual mobile station 108 to tell it to start ringing. When the BSC 50 (CCP 52) receives a connect indication from the telephone simulator 60, it sends an alert with information message to the virtual mobile station 108 to tell it to stop ringing. Once the connection has been completed, the virtual mobile station 108 notifies the controller 104 that it is in a connected state.

Figure 15 illustrates a detailed sequence of commands for a call setup for a call terminating on the virtual mobile station 108 associated with the setting up 800 of **Figure 8**. This could occur, for example, when the call is originated by a telephone number on the telephone simulator 60 or another virtual mobile station 108. The BSC 50 (CCP 52) requests a page from the virtual base station 106 to the virtual mobile station 108 indicating an incoming call to the virtual mobile station 108. The virtual base station 106 translates the IMSI of the virtual mobile station 108 to an ACN address by requesting this information from the controller 104. The virtual base station 106 pages the virtual mobile station 108. The virtual mobile station 108 responds to the page, and the virtual base station 106 forwards the response to the BSC 50 (CCP 52). The BSC 50 (SBS 56) allocates a traffic channel on the virtual base station 106 and begins sending null traffic data. The virtual base station 106 begins to forward traffic data to the virtual mobile station 108. The BSC 50 (CCP 52) assigns a channel assignment message to the virtual base station 106. The virtual base station 106 echoes this channel assignment to the virtual mobile station 108. The virtual mobile station 108 begins sending null traffic to the virtual base station 106. The virtual base station 106 sends a reverse traffic indication to the BSC 50 (SBS 56) to indicate that it is going to start sending traffic data. The BSC 50 (SBS 56) sends a base station

acknowledgement to the virtual mobile station 108. The BSC 50 (SBS 56) sends a service option response message to the virtual mobile station 108. When the BSC 50 (CCP 56) receives an alert indication from the telephone simulator 60, the BSC 50 sends an alert with information message to the virtual mobile station 108 to tell it to start ringing. The virtual mobile station 108 queries the controller 104 to find out if it is appropriate to connect. The controller 104 replies, allowing the connection to proceed. The virtual mobile station 108 responds to the alert by sending a connect signal back to the BSC 50 (SBS 56). The virtual mobile station 108 also sends a message to the controller 104 indicating that it is in a connected call.

Figure 16 illustrates a detailed sequence of commands to release a call originated by the virtual mobile station 108 associated with the teardown 1000 of **Figure 10**. The controller 104 commands the virtual mobile station 108 to release the call. The virtual mobile station 108 sends a release order to the BSC 50 (CCP 52). The BSC 50 (CCP 52) responds with a release order of its own. The virtual mobile station 108 notifies the controller 104 that it has released the call. The BSC 50 proceeds with a standard teardown sequence. The virtual base station 106 and virtual mobile station 108 reply in kind.

Figure 17 illustrates a detailed sequence of commands to release a call terminating on the virtual mobile station 108 associated with the teardown 1100 of **Figure 11**. The BSC 50 (CCP 52) sends a release order. The virtual mobile station 108 responds with a release order of its own. The virtual mobile station 108 also sends an indication to the controller 104 that the call has been released. The BSC 50 proceeds with the standard teardown sequence. The virtual base station 106 and virtual mobile station 108 reply in kind.

Figure 18 illustrates a detailed sequence of commands for a soft handoff setup and end associated with the soft handoff add 1200 and drop 1225 of **Figures 12A-B**. The controller 104 signals a pilot signal strength change. The virtual mobile station 108 sends a pilot signal strength measurement message via a first virtual base station 106(a). The BSC 50 (SBS 56) allocates resources on a second virtual base station 106(b). The BSC 50 (SBS 56) sends a traffic link count indication to both virtual base stations

106(a) and 106(b). The BSC 50 (SBS 56) starts to send traffic frames to the second virtual base station 106(b). The BSC 50 (SBS 56) sends a handoff direction message to the virtual mobile station 108 via both virtual base stations 106(a) and 106(b). The virtual mobile station 108 responds with a handoff completion message via both base stations 106(a) and 106(b). The virtual mobile station 108 lets the controller 104 know that its link count was just increased. The virtual mobile station 108 sends an indication of reverse traffic flow to the second base station 106(b). The second virtual base station 106(b) sends a reverse traffic indication to the BSC 50 (SBS 56).

While in soft handoff, the virtual mobile station will be receiving multiple copies of each traffic frame. The virtual mobile station will typically ignore duplicate copies of these frames. The controller 104 signals a pilot signal strength change. The virtual mobile station 108 sends a pilot signal strength measurement message via both virtual base stations 106(a) and 106(b). The BSC 50 (SBS 56) sends a handoff direction message sent via both virtual base stations 106(a) and 106(b). The virtual mobile station 108 responds with a handoff completion message sent via virtual base station 106(a) only. The virtual mobile station 108 lets the controller 104 know that its link count was just decreased. The BSC 50 (SBS 56) sends a traffic link count indication to virtual mobile station 108. The BSC 50 (SBS 56) stops forwarding traffic frames to virtual base station 106(b) and tells it to relinquish all resources related to the call.

Figure 19 illustrates a detailed sequence of commands for a softer handoff add 1250 and drop 1275 associated with **Figures 12C-D**. The controller 104 signals a pilot signal strength change. The virtual mobile station 108 sends a pilot signal strength measurement message via the virtual base station 106. The BSC 50 (SBS 56) allocates resources on the virtual base station 106. A traffic channel element is allocated on virtual mobile station 108. The BSC 50 (SBS 56) tells the traffic channel element to begin sending traffic data via a second sector. The BSC 50 (SBS 56) sends a handoff direction message to the virtual mobile station 108. The virtual mobile station 108 responds with a handoff completion message. The virtual mobile station 108 lets the controller 104 know that its link count was

just increased. The BSC 50 tells the virtual base station 108 to start transmitting via the second sector. Unlike the soft handoff case, the virtual mobile station will not receive multiple copies of the traffic frames. The virtual base station 108 will only send one copy of each frame even when it is acting as though the virtual mobile is receiving on two or more sectors. The controller 104 signals a pilot signal strength change. The virtual mobile station 108 sends a pilot signal strength measurement message via the virtual base station 106. The BSC 50 (SBS 56) sends a handoff direction message to the virtual mobile station 108. The virtual mobile station 108 responds with a handoff completion message. The virtual mobile station 108 lets the controller 104 know that its link count was just decreased. The BSC 50 (SBS 56) tells the traffic channel element to stop sending traffic data via the second sector. The BSC 50 tells the virtual base station 108 to deallocate resources used for the second sector.

Figure 20 is a computer 1100 which may host the controller 104, virtual base station 106, and virtual mobile station 108 in some embodiments. A central processing unit (CPU) 1102 is coupled to the computer 200 running the manager 102. The CPU 1102 may retrieve controller software from memory such as a random access memory (RAM) 1104, a read only memory (ROM) 1106, hard drive 1108 or other machine readable medium. Of course, the user 300 may enter software commands to the computer 1100 via a keyboard 1110 and view response of the computer 1100 on a monitor 1112. A typical selector bank subsystem (SBS) card has a CPU 1102 which may be programmed to behave as the controller 104.

Although only a few exemplary embodiments of this invention have been described in detail above, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be within the scope of the following claims.

I CLAIM:

CLAIMS

1. A system used in testing a mobile communications network infrastructure, the system comprising:

a test controller outputting a command signal determining a type of test to be performed;

a virtual call manipulator coupled to said test controller and responsive to said command signal and base station controller signals from a base station controller under test to provide base station test signals corresponding to said type and comparable to actual base station signals that would be generated by an actual base station and inputting said base station test signals to said base station controller under test; and

a telephone simulator coupled to said test controller and responsive to said command signal and said base station controller signals to provide test telephone signals corresponding to said type and comparable to actual telephone signals which are input to said base station controller under test.

2. A system as in claim 1 further comprising:

a manager receiving an input command from a command source and sending a system command to said test controller based on said input command, said system command determining, at least in part, said test type.

3. A system as in claim 2 wherein said manager starts said test controller by sending a start signal to said controller.

4. A system as in claim 2 wherein said manager initializes said controller by sending a start command to said controller.

5. A system as in claim 2 wherein said manager relays simulation parameters received from command sources to said controller.

6. A system as in claim 2 wherein said system command is identical to said input command.

7. A system as in claim 2 further comprising a memory such that said controller stores results of said test in said memory.

8. A system as in claim 7 wherein said manager retrieves said results from said memory

9. A system as in claim 8 wherein said manager stores said results in a second memory.

10. A system used in testing a mobile communications network infrastructure, the simulator comprising:

a test controller outputting a command signal indicating a type of test to be performed;

a virtual base station providing base station test signals corresponding to said type and comparable to actual base station signals that would be generated by an actual base station and inputting said base station test signals to a base station controller under test; and

a virtual mobile station responsive to said command signal and to said base station test signals to provide mobile station test signals corresponding to said type and comparable to actual mobile station signals that would be generated by an actual mobile station;

wherein said virtual base station interfaces, at least in part, said virtual mobile station with said base station controller under test by accepting said mobile station test signals, said command signal, and said base station controller signals to provide said base station test signals.

11. A system as in claim 10 further comprising a manager receiving an input command from a command source and sending a system command to said test controller based on said input command, said system command determining, at least in part, said test type wherein said manager initializes said virtual base station by sending a base station initialization command to said virtual base station.

12. A system as in claim 11 wherein said manager initializes said virtual mobile station by sending a mobile station initialization command to said virtual mobile station.

13. A system as in claim 10 further comprising a memory such that said controller stores results of said test in said memory.

14. A system as in claim 10 wherein said system command is identical to said input command.

15. A system as in claim 10 further comprising a memory wherein said controller maintains a database of information about said virtual mobile station by sending signals to and receiving signals from said virtual mobile station and by storing said information in said memory.

16. A system as in claim 15 wherein said information includes one or more of the following: addresses of components under test, location, list of base station links to said virtual mobile station, call status, handoff status, neighboring sectors, calculated pilot strengths, IS-95A information.

17. A system as in claim 16 wherein said memory stores data regarding said test under control of said controller.

18. A system as in claim 17 wherein said controller stores overhead channel information in said memory.

19. A system as in claim 17 wherein said controller updates said channel information stored in said memory when said channel information changes.

20. A system as in claim 10 wherein said controller is capable of creating a second virtual mobile station.

21. A system as in claim 20 wherein said controller may switch communication between handoffs.

22. A method of testing a communications network by simulating a call, the method comprising:

simulating a call between a virtual call manipulator and a telephone number via a base station controller under test; and

outputting information regarding said call.

23. A method of testing as in claim 22 wherein said simulating includes setting up said call.

24. A method of testing as in claim 23 wherein said setting up includes performing a handshake between said base station controller and said virtual call manipulator.

25. A method of testing as in claim 23 wherein said virtual call manipulator includes a virtual mobile station and a virtual base station and wherein said setting up includes sending a setup command to said virtual mobile station.

26. A method of testing as in claim 25 wherein said setting up includes performing a handshake between said virtual base station and said virtual mobile station.

27. A method of testing as in claim 26 wherein said virtual call manipulator includes a second virtual mobile station and wherein said setting up includes performing a handshake between said virtual base station and a second virtual mobile station.

28. A method of testing as in claim 27 wherein said setting up includes notifying a controller of an incoming call on said second virtual mobile station.

29. A method of testing as in claim 27 wherein said setting up includes sending a receive command to said second virtual mobile station.

30. A method as in claim 23 wherein said setting up includes allocating resources on said virtual base station to enable said call to be simulated.

31. A method of testing as in claim 22 wherein said simulating includes tearing down said call.

32. A method of testing as in claim 31 wherein said tearing down includes sending a release command to said virtual call manipulator.

33. A method of testing as in claim 22 wherein said virtual call manipulator includes a virtual mobile station and first and second virtual base stations such that said virtual mobile station and said first virtual base station are engaged in said call, wherein said simulating includes handing off said call from said first virtual base station to said second virtual base station.

34. A method of testing as in claim 33 wherein said simulating includes sending a pilot strength change command to said virtual mobile station

35. A method of testing as in claim 33 wherein said handing off includes sending a resource request to said second virtual base station

36. A method of testing as in claim 33 wherein said handing off includes sending a release order for a first virtual base station to said virtual mobile station

37. A method of testing as in claim 36 wherein said handing off includes acknowledging said release order

38. A method of testing as in claim 33 wherein said handing off includes updating link information.

39. A method as recited in claim 33 wherein said handing off includes measuring a pilot signal strength on said first virtual base station.

40. A method as recited in claim 33 wherein said handing off includes allocating resources on said second virtual base station.

41. A method as recited in claim 33 wherein said handing off includes measuring a pilot signal strength on said second virtual base station.

42. A method as recited in claim 22 wherein said outputting includes displaying said information on a computer screen.

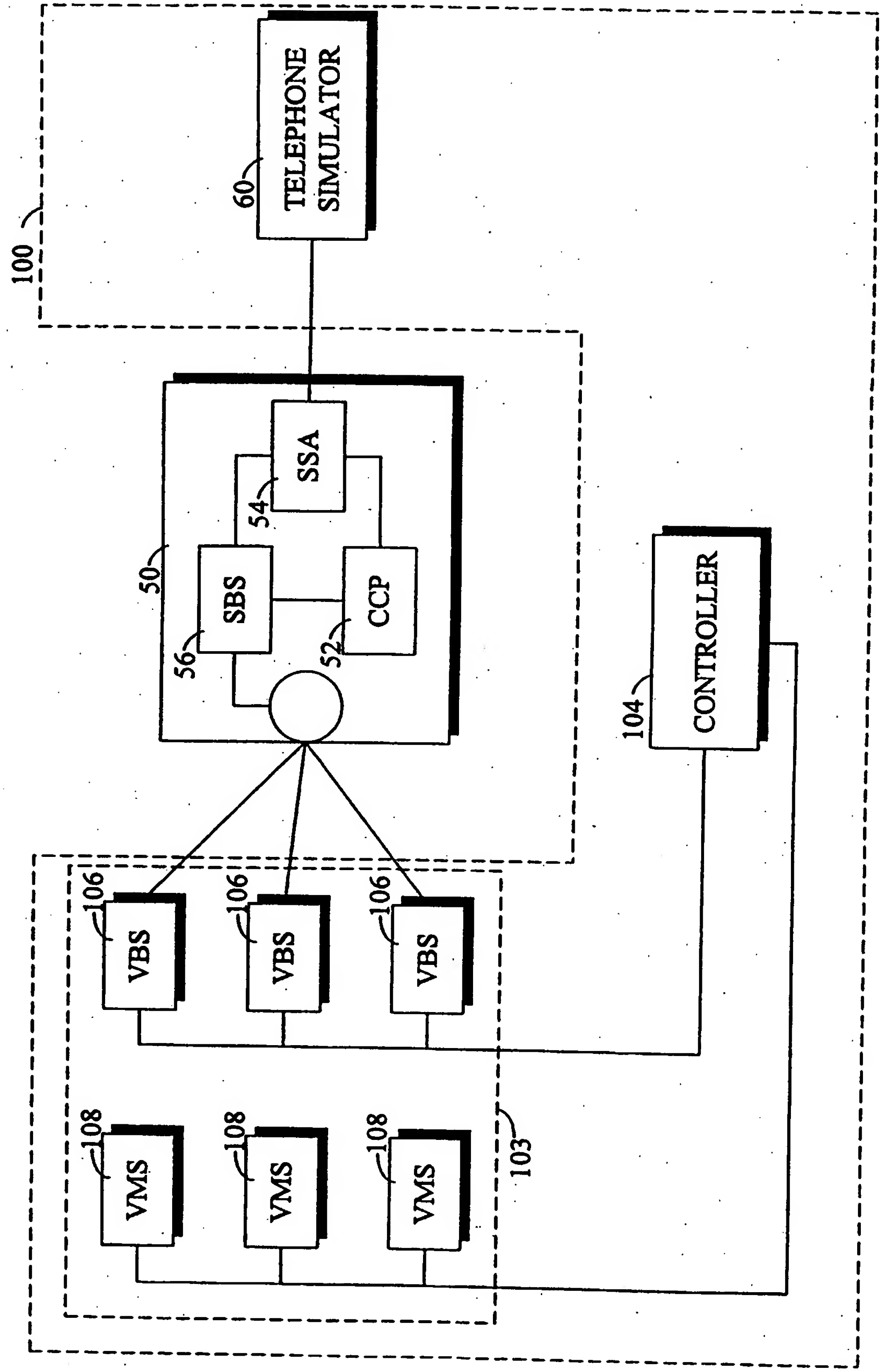

100
60
TELEPHONE SIMULATOR
50
SSA
54
SBS
56
CCP
52
104
CONTROLLER
106
VBS
106
VBS
106
VBS
108
VMS
108
VMS
108
VMS
103

FIGURE 1

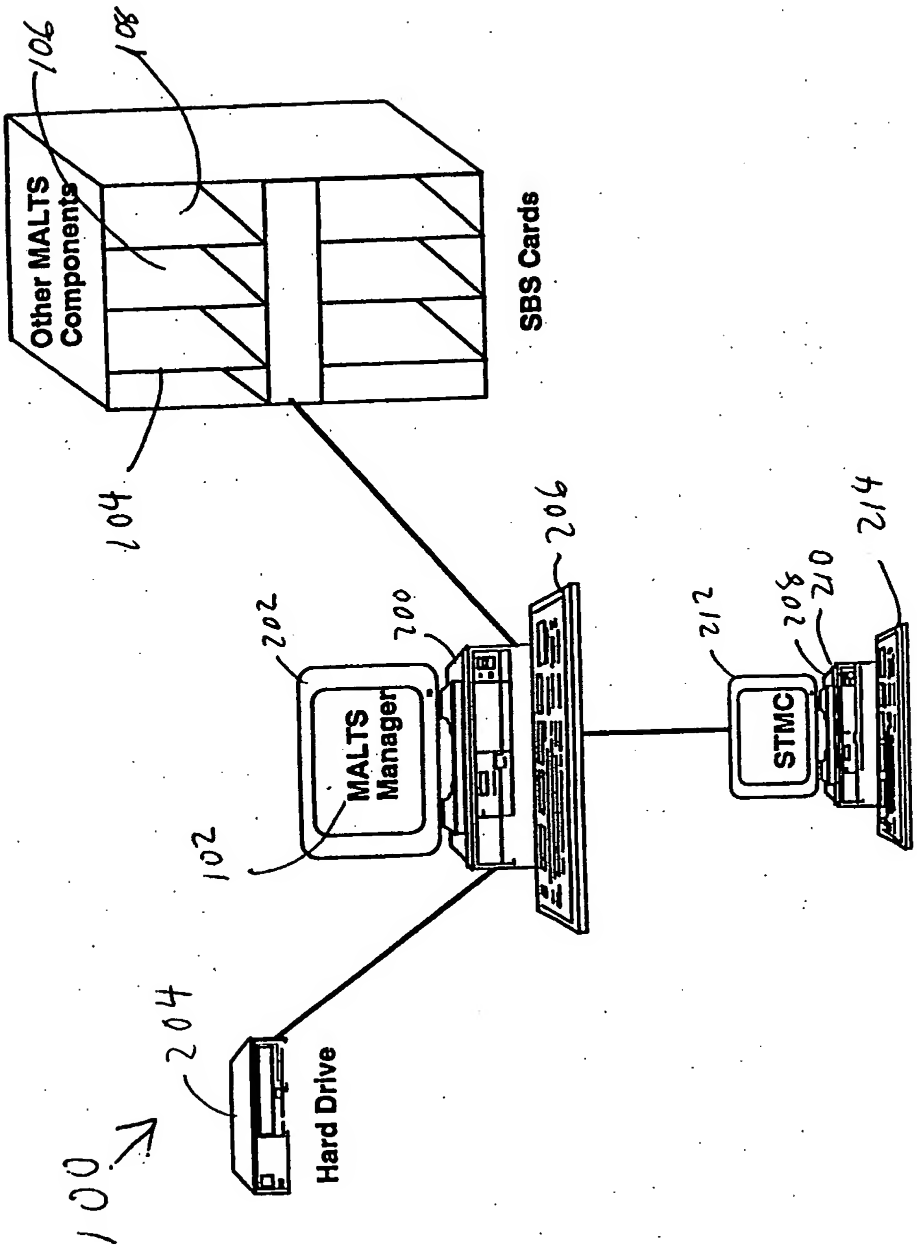

Other MALTS Components
SBS Cards
MALTS Manager
STMC
Hard Drive
100
102
104
106
108
200
202
204
206
208
210
212
214

Figure 2

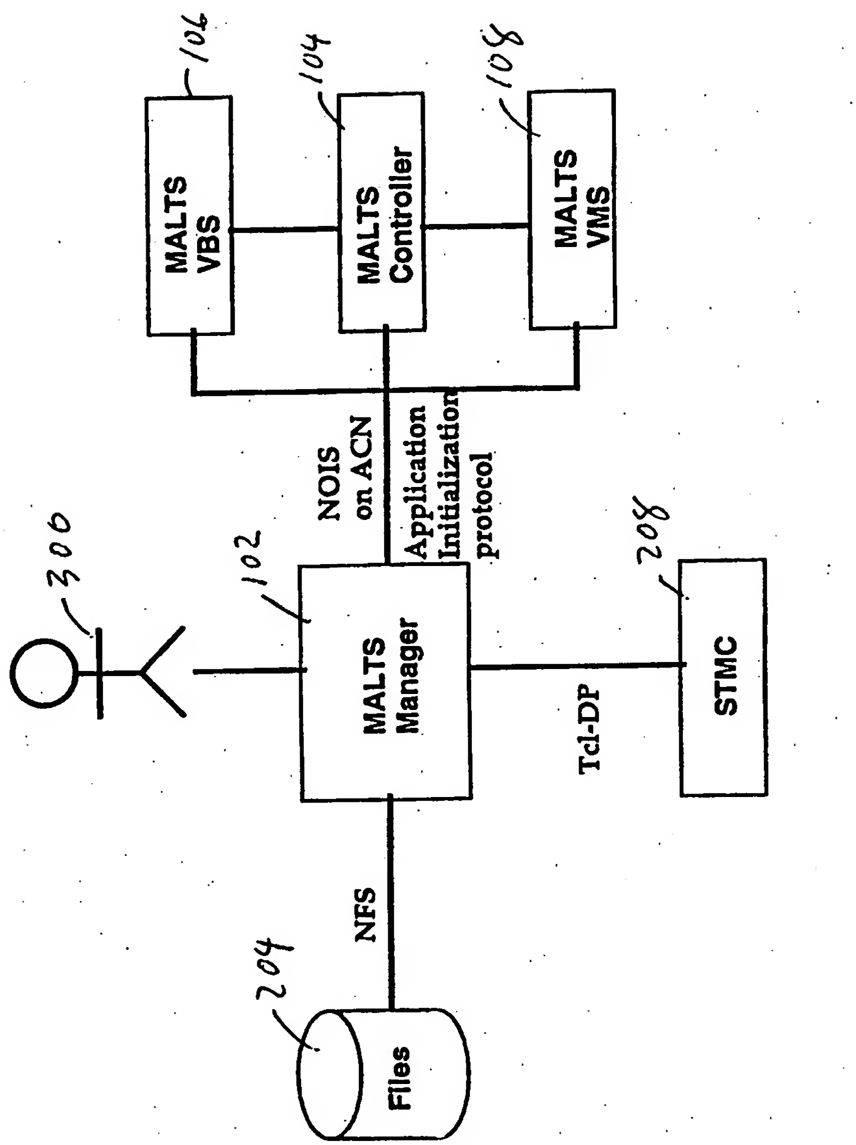

MALTS VBS
MALTS Controller
MALTS VMS
106
104
108
NOIS on ACN
Application Initialization protocol
300
102
MALTS Manager
208
Tcl-DP
STMC
NFS
204
Files

Figure 3

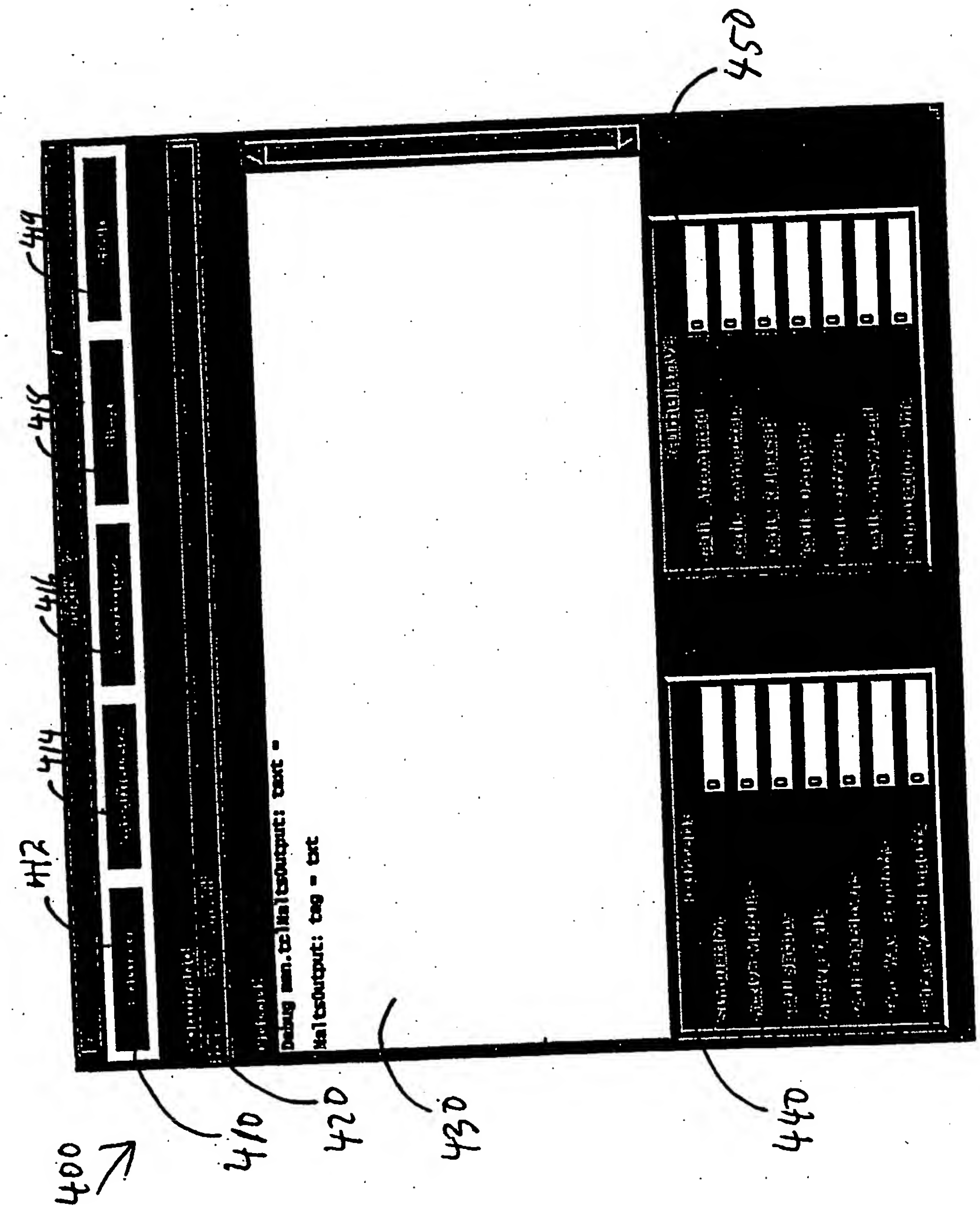

400
410
412
414
416
418
419
420
430
440
450
Debug man.tclWaltsOutput: txt =
WaltsOutput: tag = txt

Figure 4

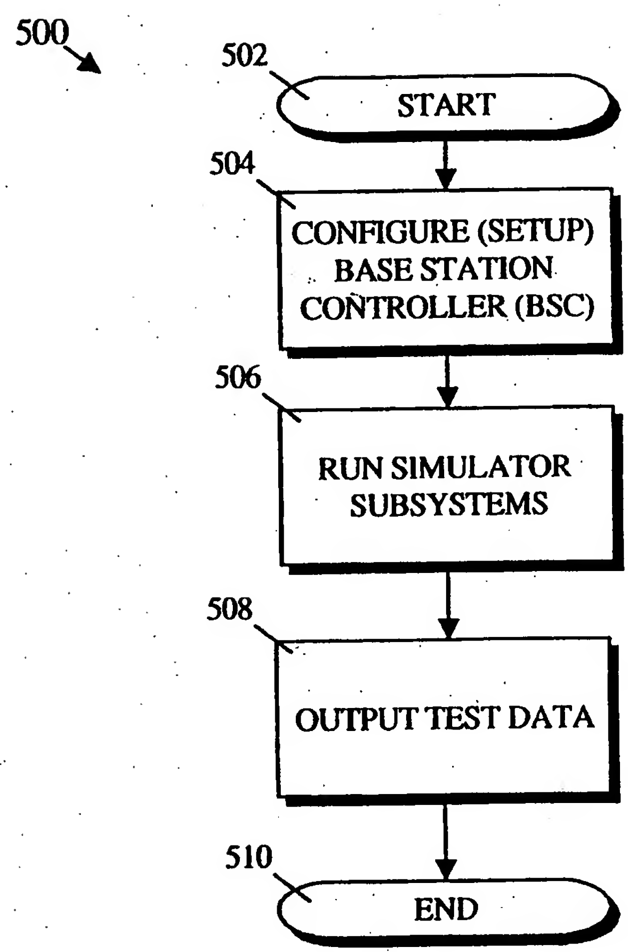

500
502
START
504
CONFIGURE (SETUP) BASE STATION CONTROLLER (BSC)
506
RUN SIMULATOR SUBSYSTEMS
508
OUTPUT TEST DATA
510
END

Figure 5

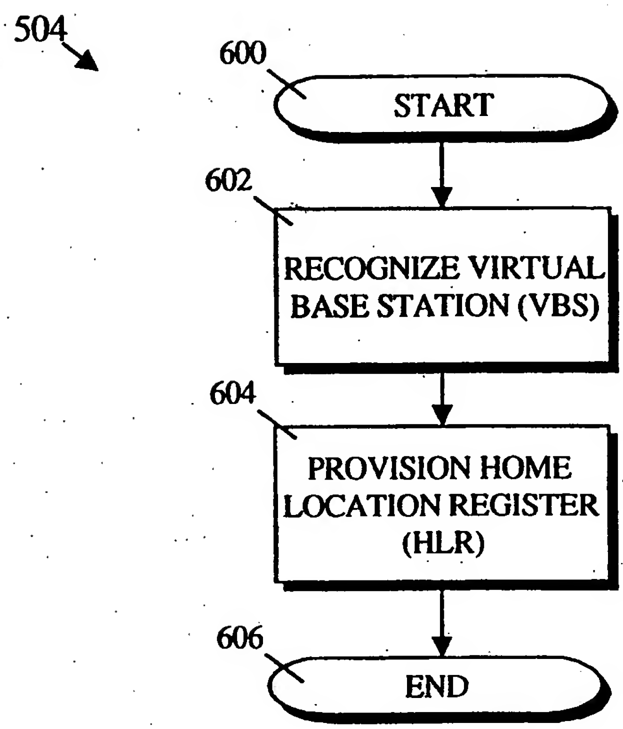

504
600
START
602
RECOGNIZE VIRTUAL BASE STATION (VBS)
604
PROVISION HOME LOCATION REGISTER (HLR)
606
END

Figure 6

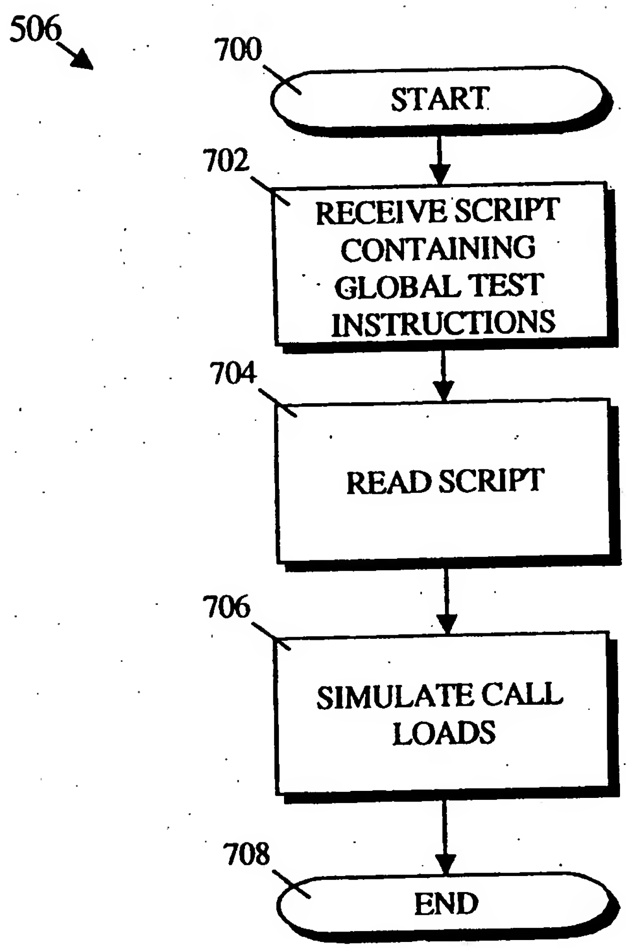

506
700
START
702
RECEIVE SCRIPT CONTAINING GLOBAL TEST INSTRUCTIONS
704
READ SCRIPT
706
SIMULATE CALL LOADS
708
END

Figure 7

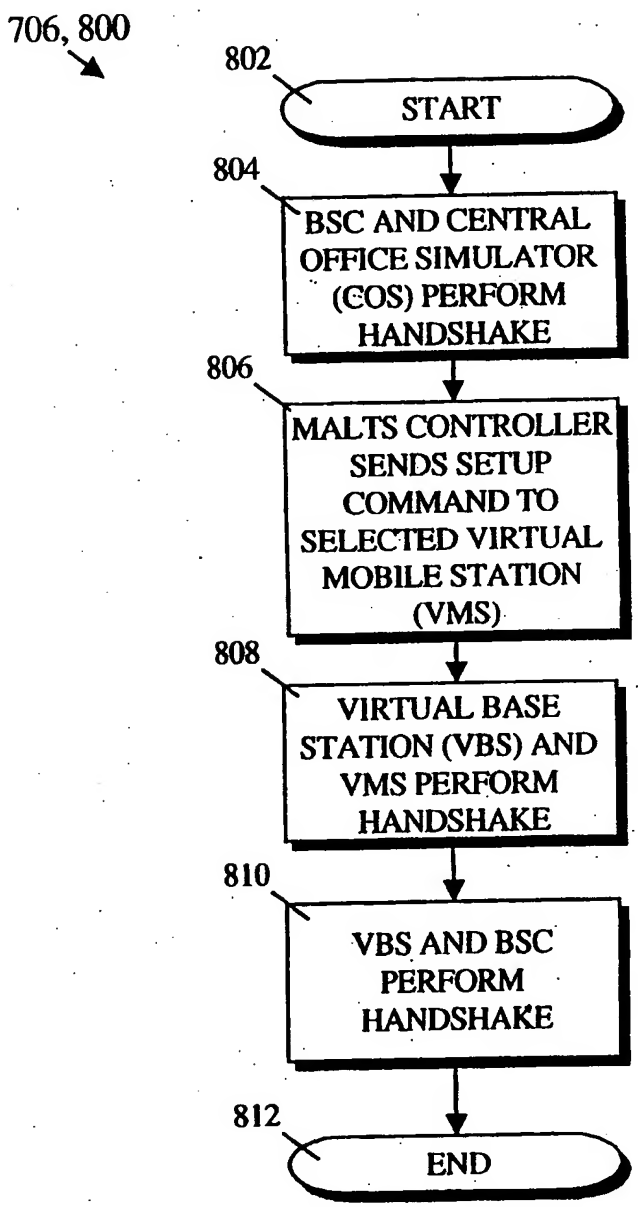
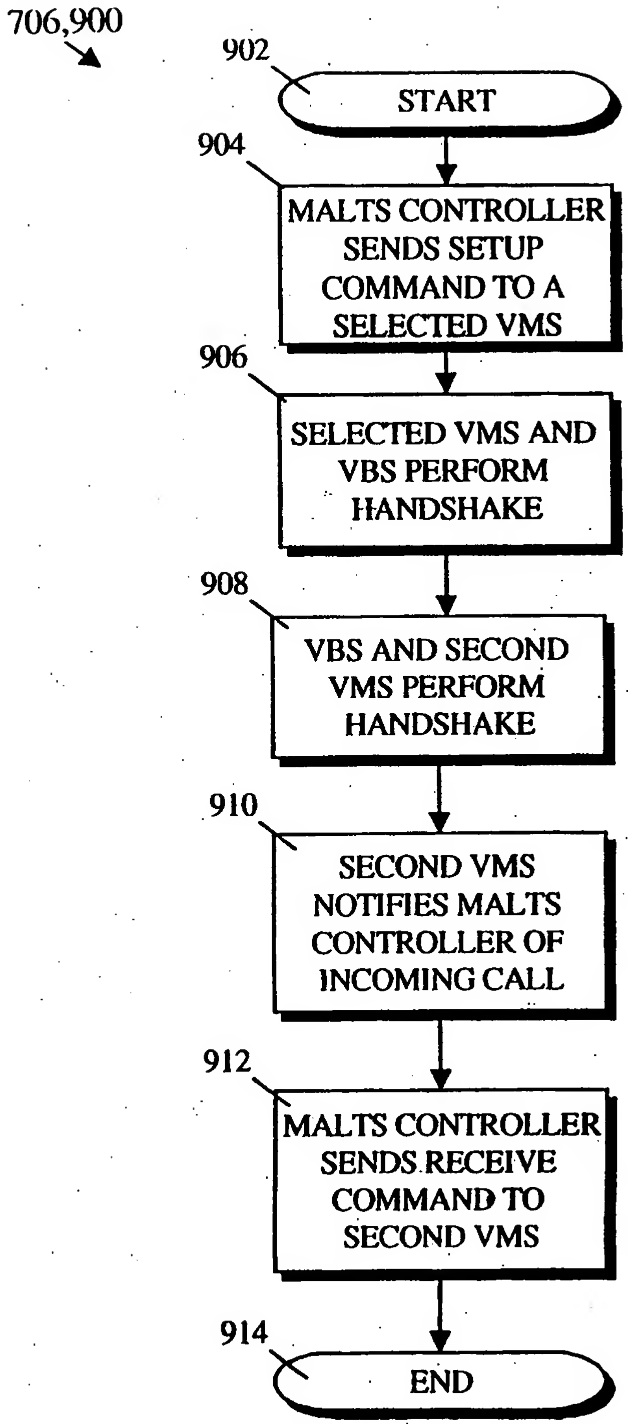

706, 800
802
START
804
BSC AND CENTRAL OFFICE SIMULATOR (COS) PERFORM HANDSHAKE
806
MALTS CONTROLLER SENDS SETUP COMMAND TO SELECTED VIRTUAL MOBILE STATION (VMS)
808
VIRTUAL BASE STATION (VBS) AND VMS PERFORM HANDSHAKE
810
VBS AND BSC PERFORM HANDSHAKE
812
END

Figure 8



706,900
902
START
904
MALTS CONTROLLER SENDS SETUP COMMAND TO A SELECTED VMS
906
SELECTED VMS AND VBS PERFORM HANDSHAKE
908
VBS AND SECOND VMS PERFORM HANDSHAKE
910
SECOND VMS NOTIFIES MALTS CONTROLLER OF INCOMING CALL
912
MALTS CONTROLLER SENDS RECEIVE COMMAND TO SECOND VMS
914
END

Figure 9

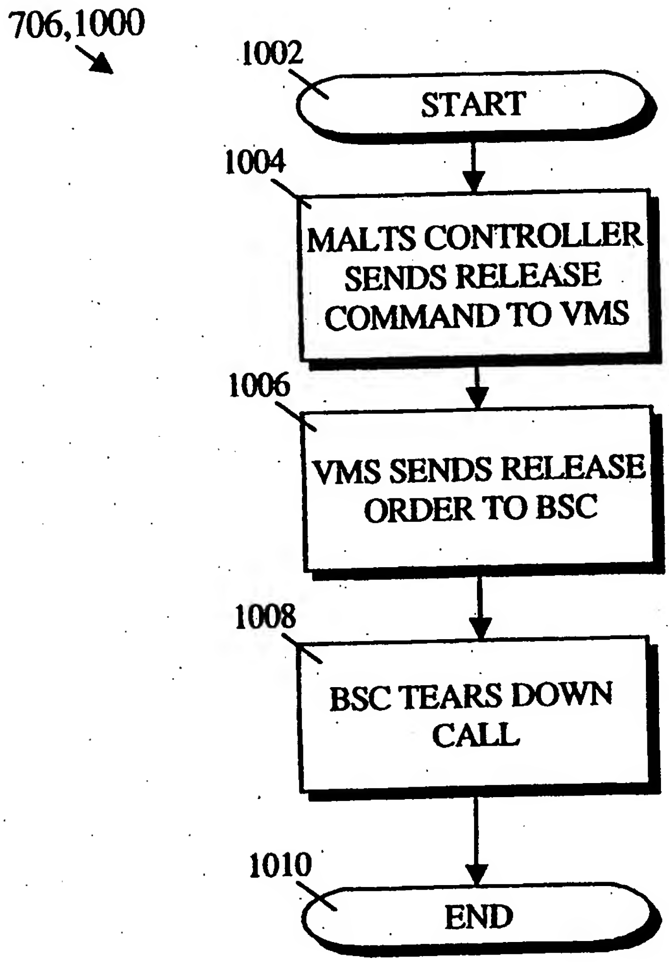

706,1000
1002
START
1004
MALTS CONTROLLER SENDS RELEASE COMMAND TO VMS
1006
VMS SENDS RELEASE ORDER TO BSC
1008
BSC TEARS DOWN CALL
1010
END

Figure 10

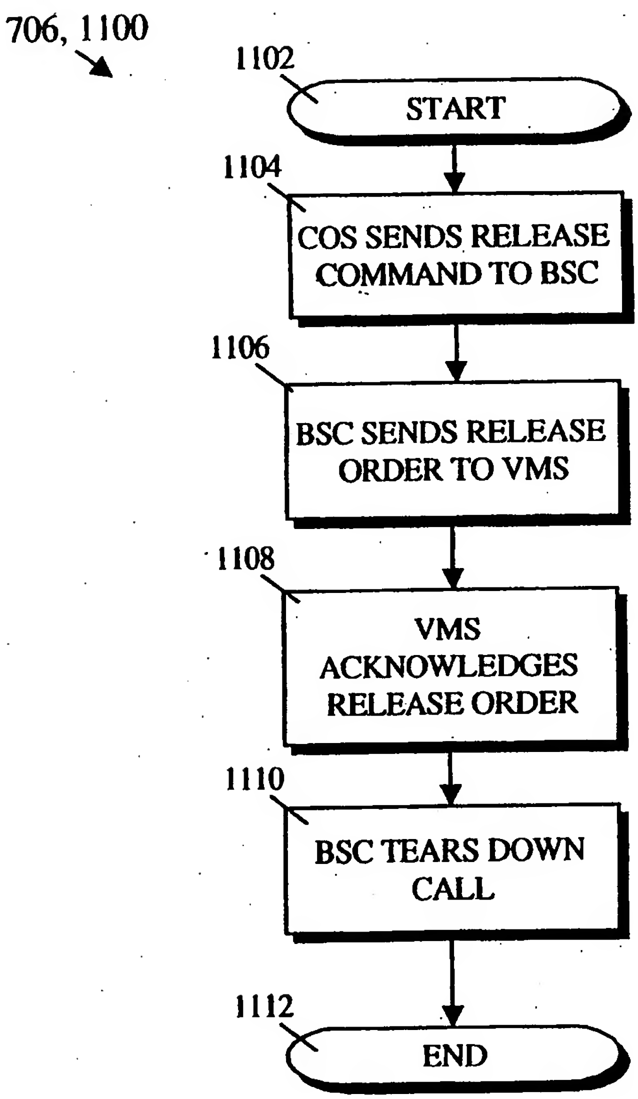

706, 1100
1102
START
1104
COS SENDS RELEASE COMMAND TO BSC
1106
BSC SENDS RELEASE ORDER TO VMS
1108
VMS ACKNOWLEDGES RELEASE ORDER
1110
BSC TEARS DOWN CALL
1112
END

Figure 11

706,1200

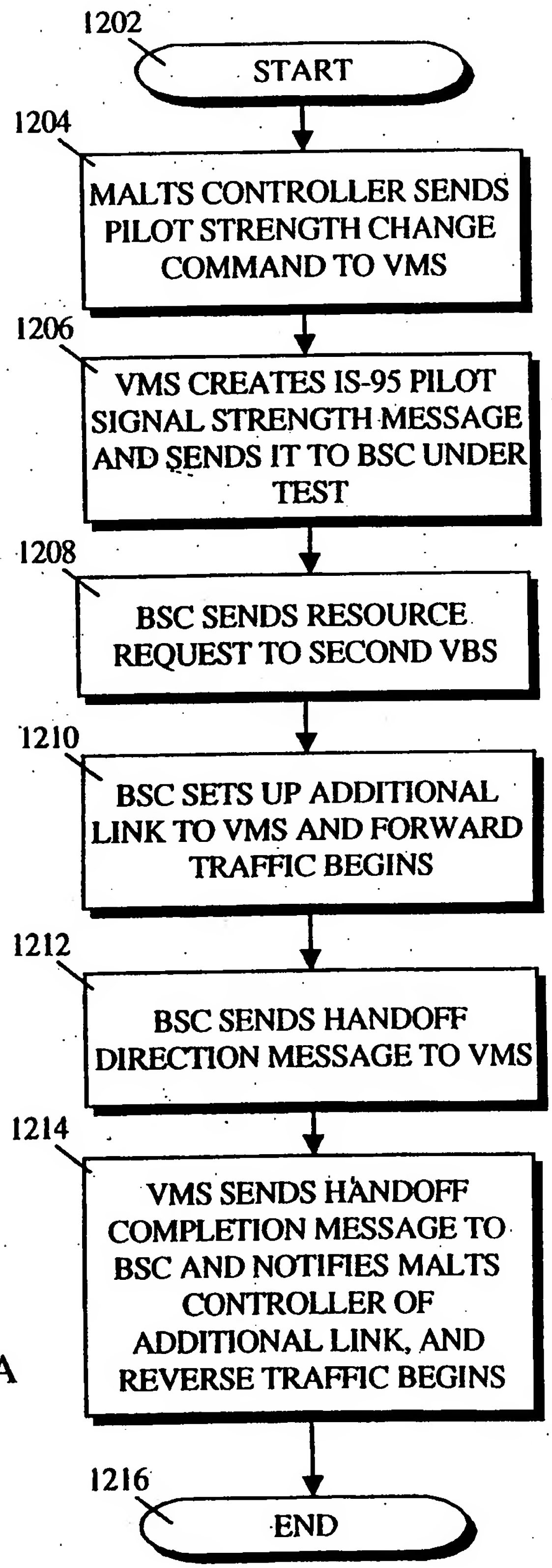


Figure 12A

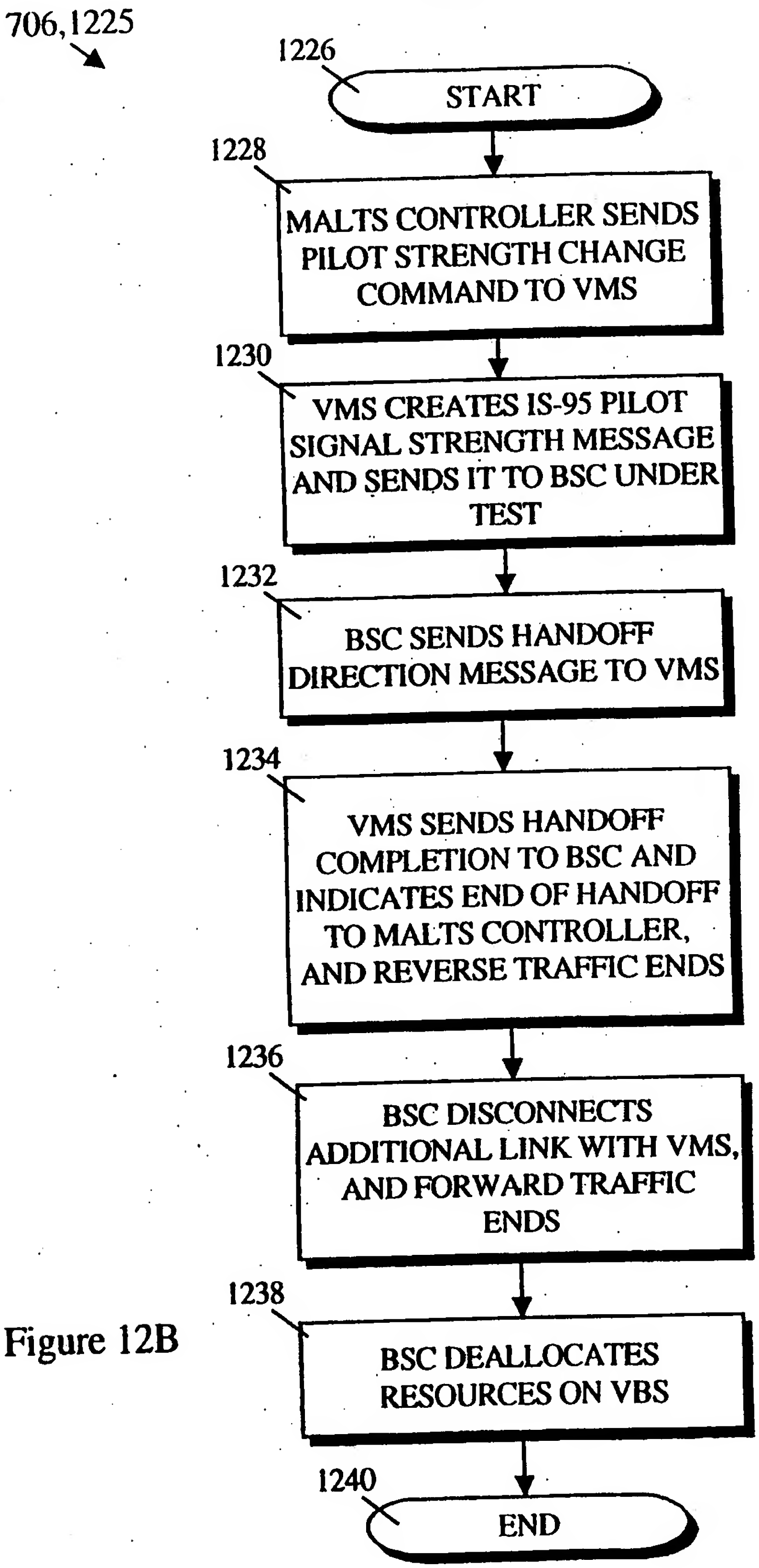

706,1225
1226
START
1228
MALTS CONTROLLER SENDS PILOT STRENGTH CHANGE COMMAND TO VMS
1230
VMS CREATES IS-95 PILOT SIGNAL STRENGTH MESSAGE AND SENDS IT TO BSC UNDER TEST
1232
BSC SENDS HANDOFF DIRECTION MESSAGE TO VMS
1234
VMS SENDS HANDOFF COMPLETION TO BSC AND INDICATES END OF HANDOFF TO MALTS CONTROLLER, AND REVERSE TRAFFIC ENDS
1236
BSC DISCONNECTS ADDITIONAL LINK WITH VMS, AND FORWARD TRAFFIC ENDS
1238
BSC DEALLOCATES RESOURCES ON VBS
1240
END

Figure 12B

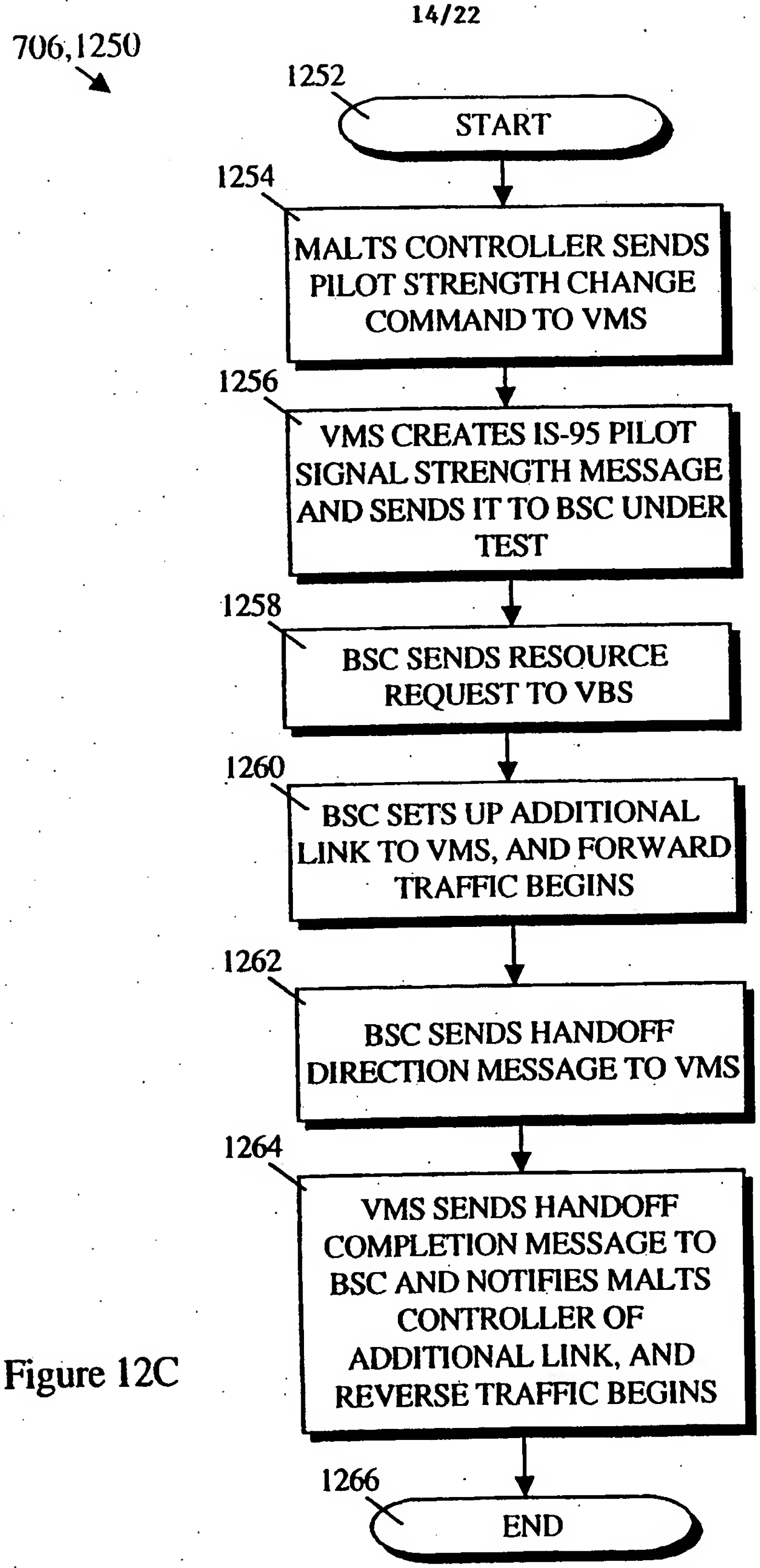

706,1250
1252
START
1254
MALTS CONTROLLER SENDS PILOT STRENGTH CHANGE COMMAND TO VMS
1256
VMS CREATES IS-95 PILOT SIGNAL STRENGTH MESSAGE AND SENDS IT TO BSC UNDER TEST
1258
BSC SENDS RESOURCE REQUEST TO VBS
1260
BSC SETS UP ADDITIONAL LINK TO VMS, AND FORWARD TRAFFIC BEGINS
1262
BSC SENDS HANDOFF DIRECTION MESSAGE TO VMS
1264
VMS SENDS HANDOFF COMPLETION MESSAGE TO BSC AND NOTIFIES MALTS CONTROLLER OF ADDITIONAL LINK, AND REVERSE TRAFFIC BEGINS
1266
END

Figure 12C

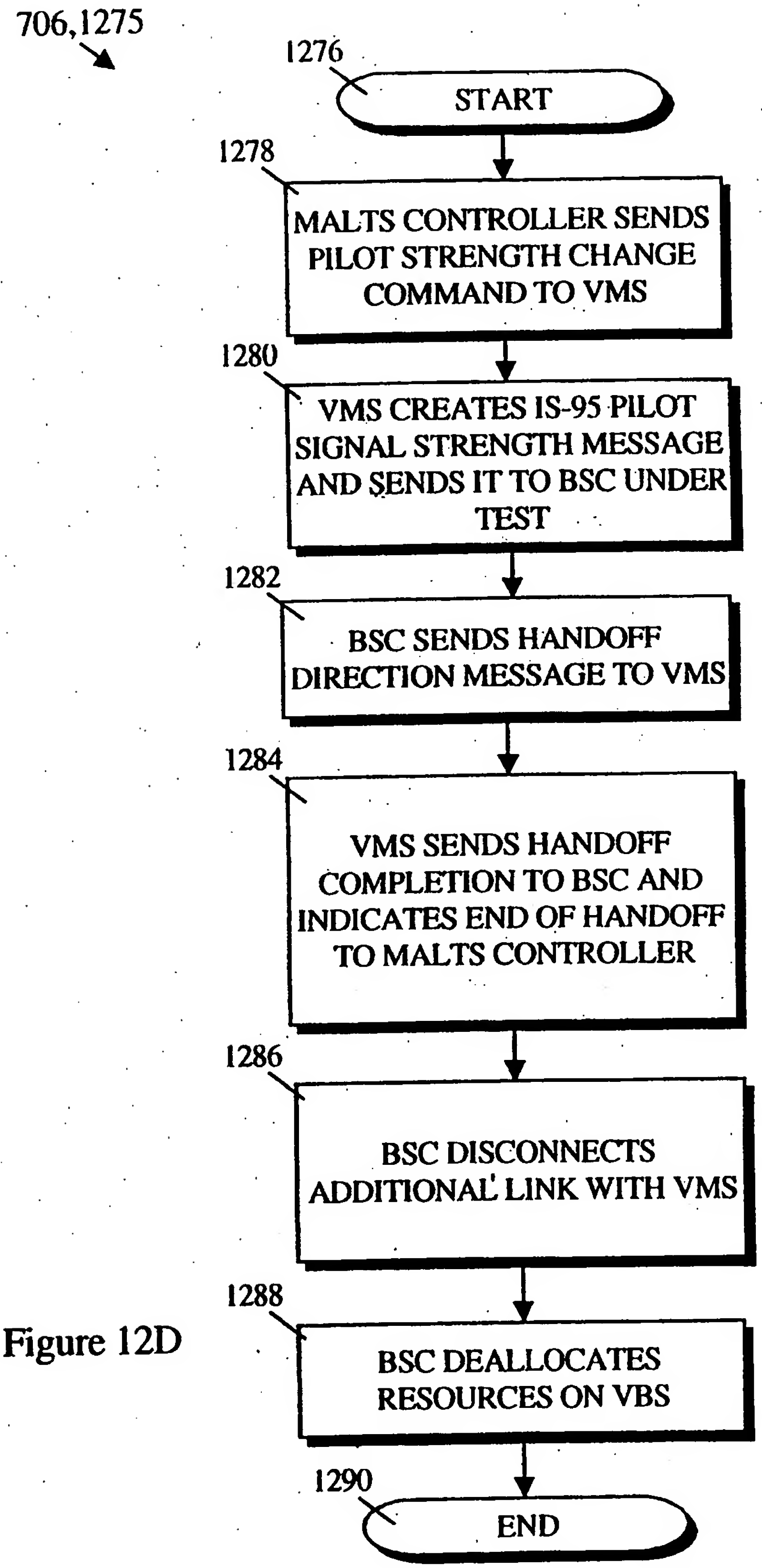

706,1275
1276
START
1278
MALTS CONTROLLER SENDS PILOT STRENGTH CHANGE COMMAND TO VMS
1280
VMS CREATES IS-95 PILOT SIGNAL STRENGTH MESSAGE AND SENDS IT TO BSC UNDER TEST
1282
BSC SENDS HANDOFF DIRECTION MESSAGE TO VMS
1284
VMS SENDS HANDOFF COMPLETION TO BSC AND INDICATES END OF HANDOFF TO MALTS CONTROLLER
1286
BSC DISCONNECTS ADDITIONAL LINK WITH VMS
1288
BSC DEALLOCATES RESOURCES ON VBS
1290
END

Figure 12D

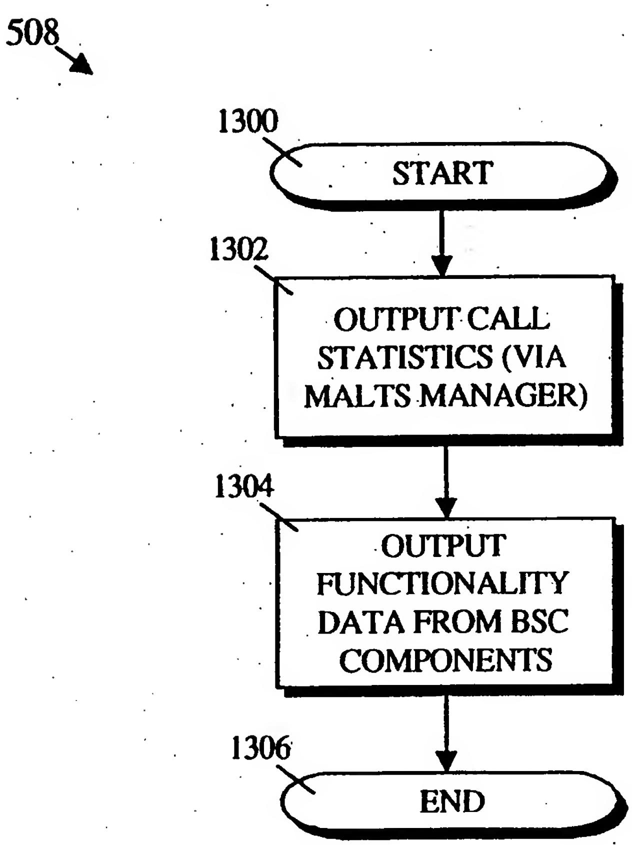

508
1300
START
1302
OUTPUT CALL STATISTICS (VIA MALTS MANAGER)
1304
OUTPUT FUNCTIONALITY DATA FROM BSC COMPONENTS
1306
END

Figure 13

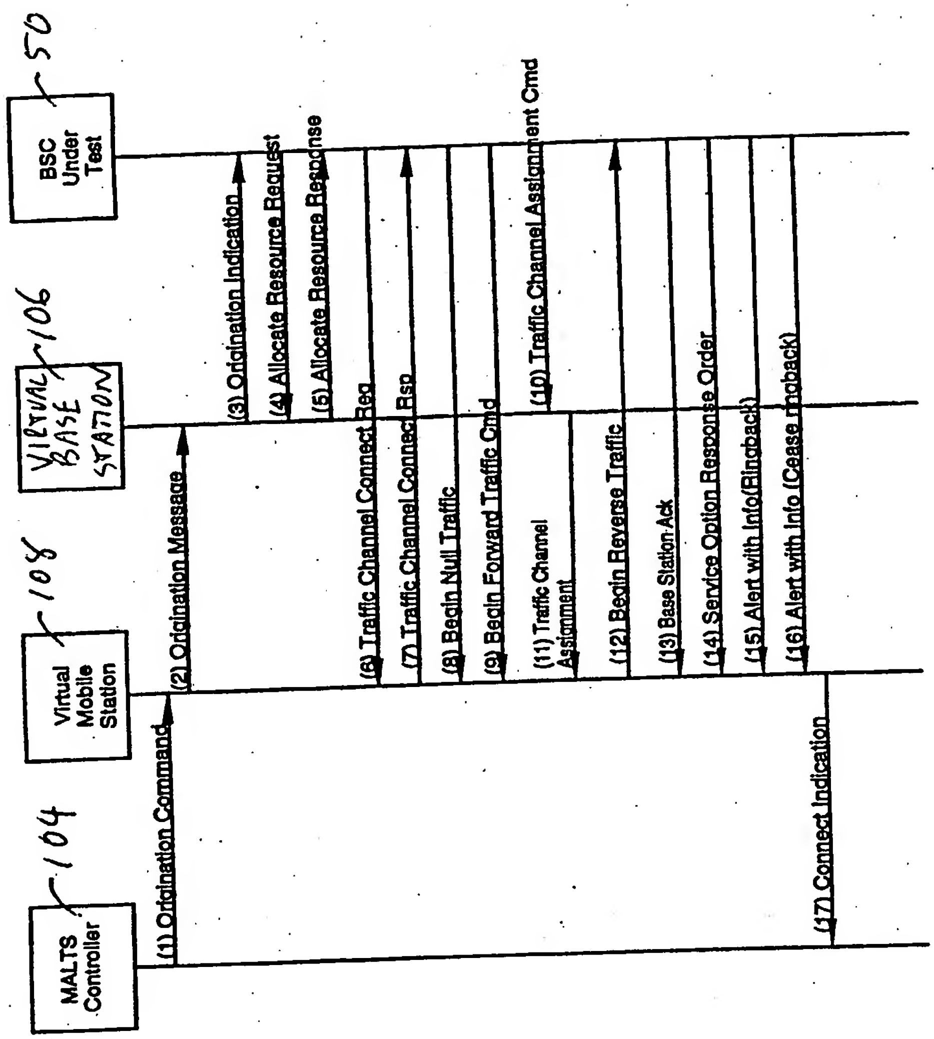
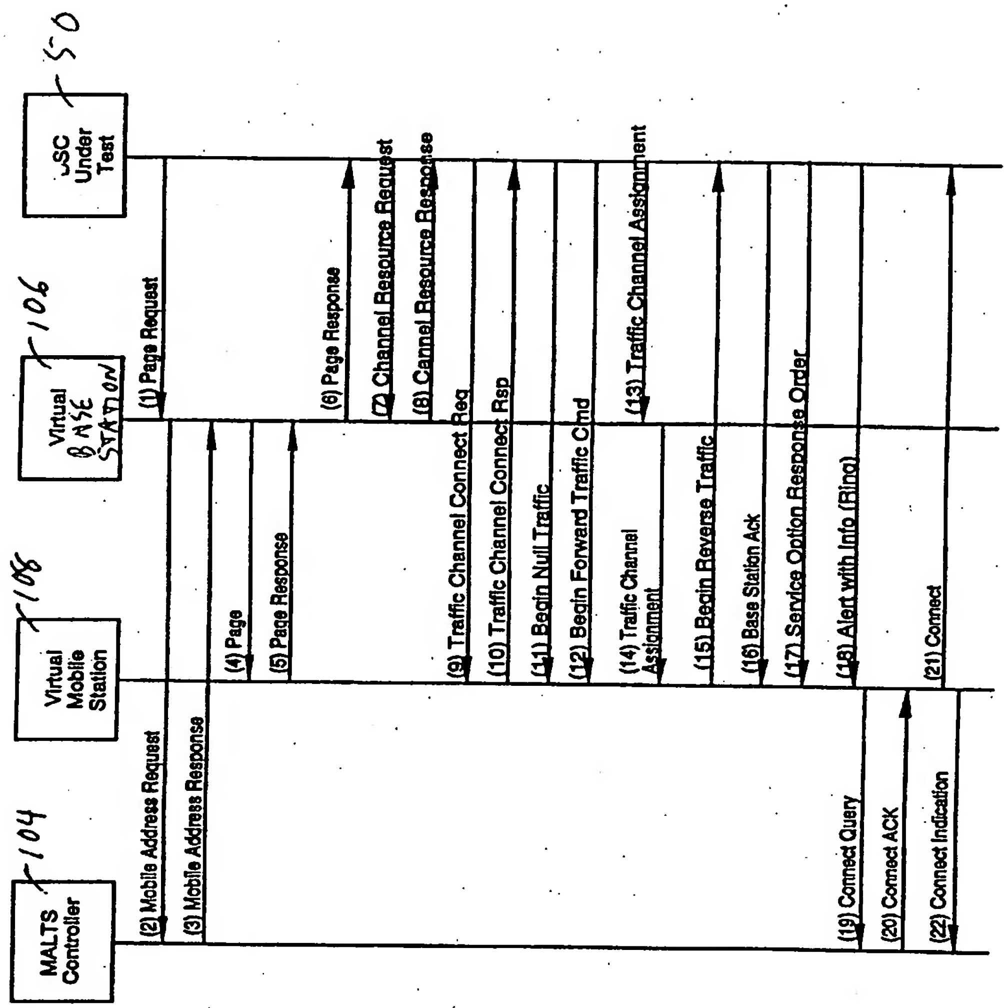

MALTS Controller
104
Virtual Mobile Station
108
VIRTUAL BASE STATION
106
BSC Under Test
50
(1) Origination Command
(2) Origination Message
(3) Origination Indication
(4) Allocate Resource Request
(5) Allocate Resource Response
(6) Traffic Channel Connect Req
(7) Traffic Channel Connect Rsp
(8) Begin Null Traffic
(9) Begin Forward Traffic Cmd
(10) Traffic Channel Assignment Cmd
(11) Traffic Channel Assignment
(12) Begin Reverse Traffic
(13) Base Station Ack
(14) Service Option Response Order
(15) Alert with Info (Ringback)
(16) Alert with Info (Cease ringback)
(17) Connect Indication

Figure 14



MALTS Controller
104
Virtual Mobile Station
108
Virtual BASE STATION
106
USC Under Test
50
(1) Page Request
(2) Mobile Address Request
(3) Mobile Address Response
(4) Page
(5) Page Response
(6) Page Response
(7) Channel Resource Request
(8) Cannel Resource Response
(9) Traffic Channel Connect Req
(10) Traffic Channel Connect Rsp
(11) Begin Null Traffic
(12) Begin Forward Traffic Cmd
(13) Traffic Channel Assignment
(14) Traffic Channel Assignment
(15) Begin Reverse Traffic
(16) Base Station Ack
(17) Service Option Response Order
(18) Alert with Info (Ring)
(19) Connect Query
(20) Connect ACK
(21) Connect
(22) Connect Indication

Figure 15

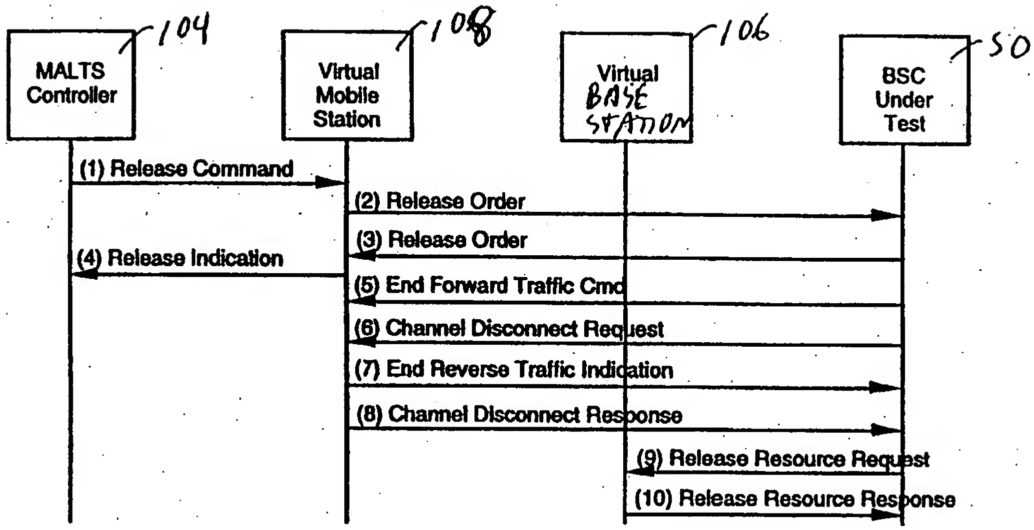


Figure 16

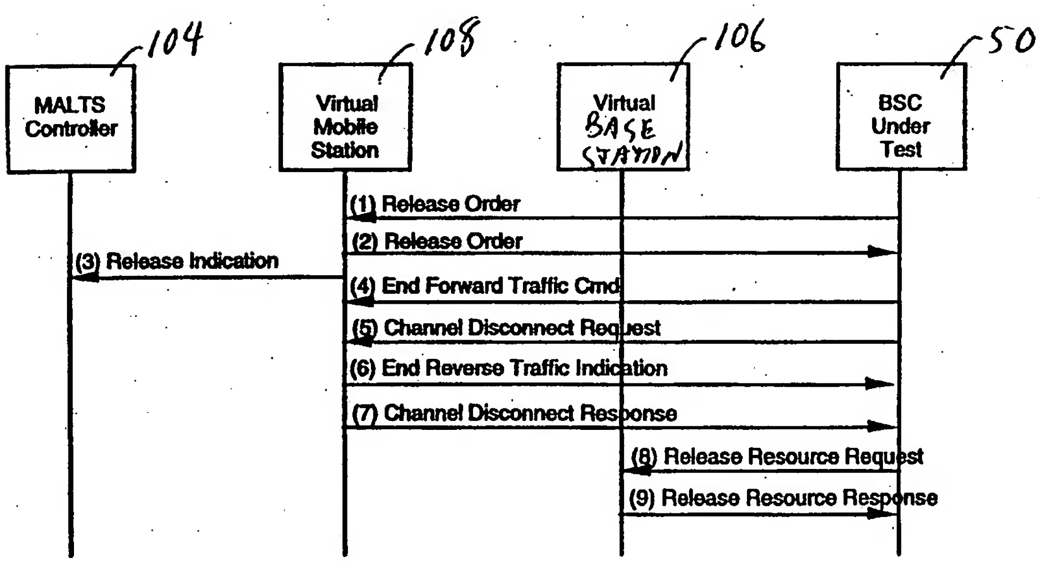


Figure 17

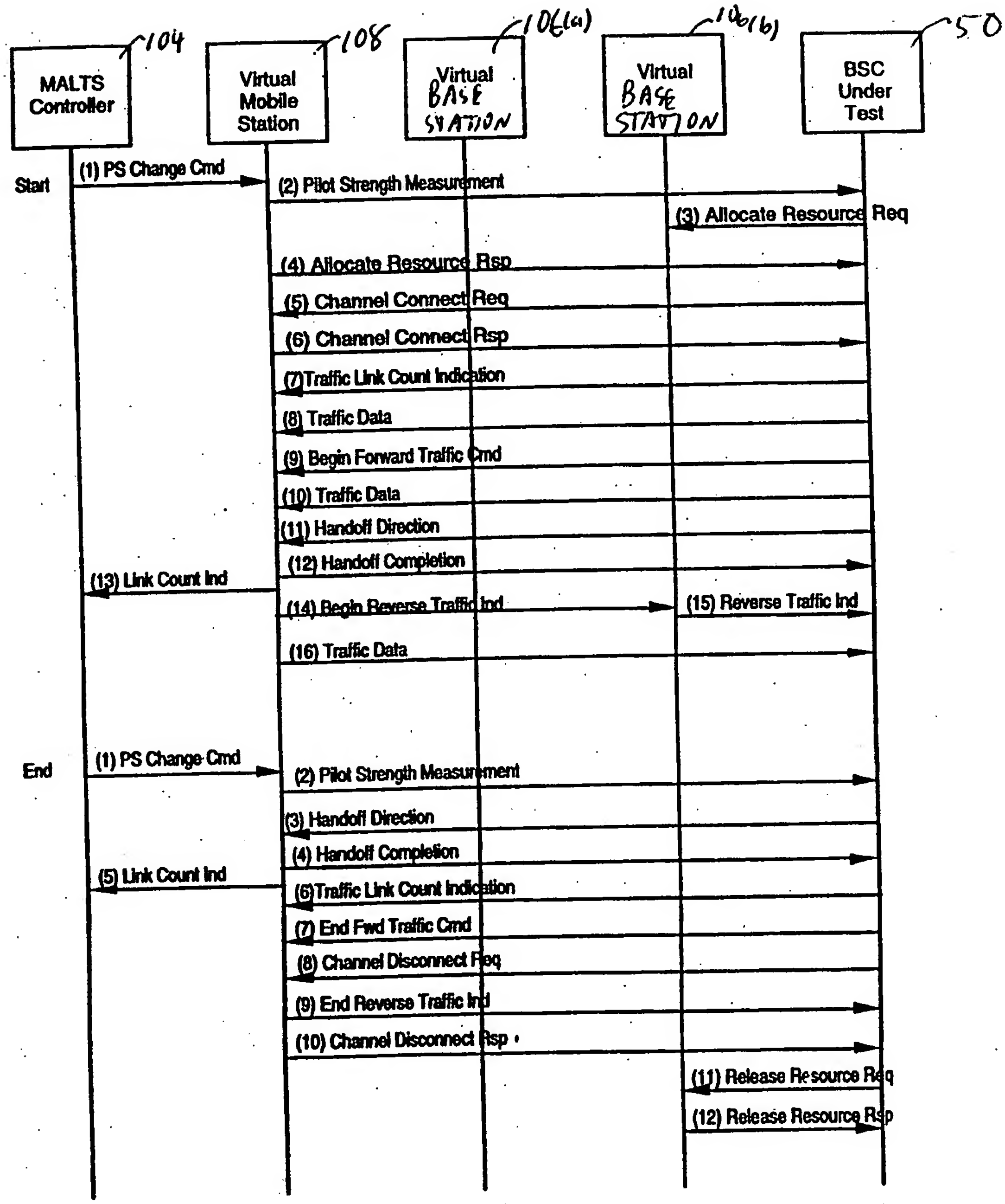

104
108
106(a)
106(b)
50
MALTS Controller
Virtual Mobile Station
Virtual BASE STATION
Virtual BASE STATION
BSC Under Test
Start
(1) PS Change Cmd
(2) Pilot Strength Measurement
(3) Allocate Resource Req
(4) Allocate Resource Rsp
(5) Channel Connect Req
(6) Channel Connect Rsp
(7)Traffic Link Count Indication
(8) Traffic Data
(9) Begin Forward Traffic Cmd
(10) Traffic Data
(11) Handoff Direction
(12) Handoff Completion
(13) Link Count Ind
(14) Begin Reverse Traffic Ind
(15) Reverse Traffic Ind
(16) Traffic Data
End
(1) PS Change Cmd
(2) Pilot Strength Measurement
(3) Handoff Direction
(4) Handoff Completion
(5) Link Count Ind
(6)Traffic Link Count Indication
(7) End Fwd Traffic Cmd
(8) Channel Disconnect Req
(9) End Reverse Traffic Ind
(10) Channel Disconnect Rsp
(11) Release Resource Req
(12) Release Resource Rsp

Figure 18

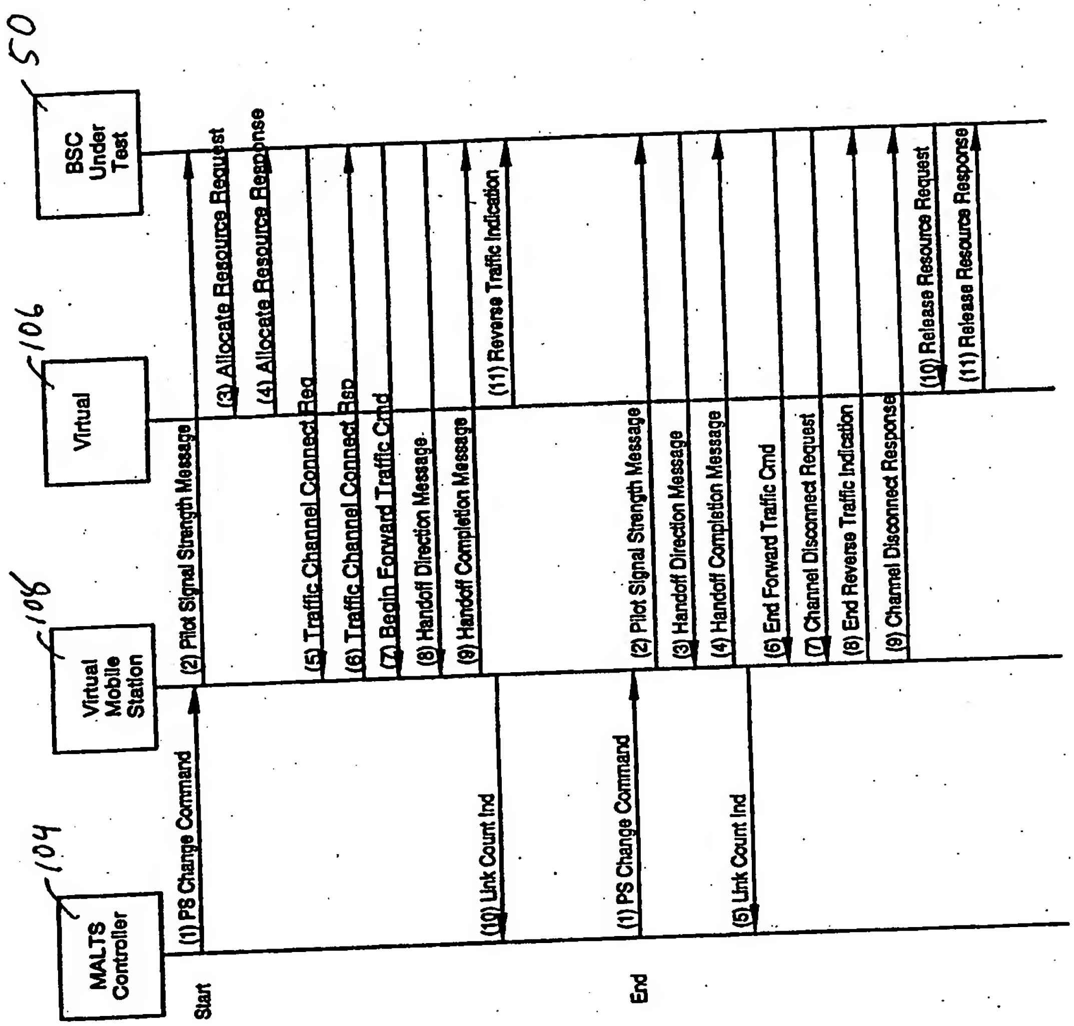

MALTS Controller
104
Virtual Mobile Station
108
Virtual
106
BSC Under Test
50
Start
End
(1) PS Change Command
(2) Pilot Signal Strength Message
(3) Allocate Resource Request
(4) Allocate Resource Response
(5) Traffic Channel Connect Req
(6) Traffic Channel Connect Rsp
(7) Begin Forward Traffic Cmd
(8) Handoff Direction Message
(9) Handoff Completion Message
(10) Link Count Ind
(11) Reverse Traffic Indication
(1) PS Change Command
(2) Pilot Signal Strength Message
(3) Handoff Direction Message
(4) Handoff Completion Message
(5) Link Count Ind
(6) End Forward Traffic Cmd
(7) Channel Disconnect Request
(8) End Reverse Traffic Indication
(9) Channel Disconnect Response
(10) Release Resource Request
(11) Release Resource Response

Figure 19

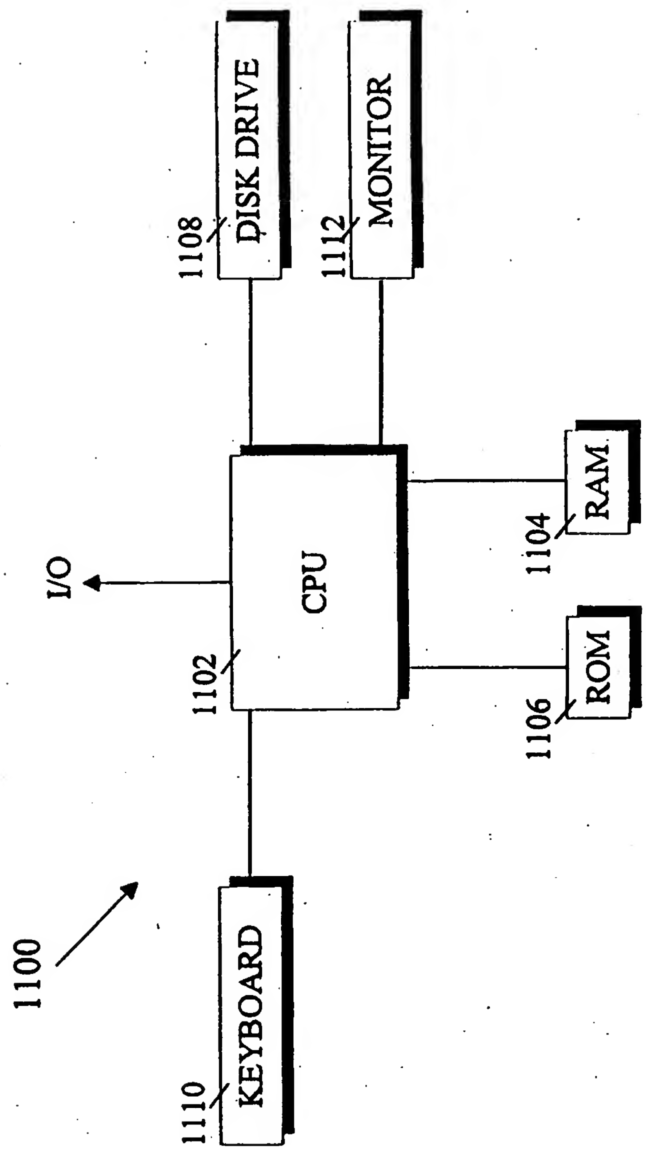

1100
KEYBOARD
1110
1102
CPU
I/O
DISK DRIVE
1108
MONITOR
1112
RAM
1104
ROM
1106

Figure 20

INTERNATIONAL SEARCH REPORT

Inte   ional Application No
PCT/US 99/07351

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04Q7/34

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 589 576 A (AMERICAN TELEPHONE & TELEGRAPH) 30 March 1994 (1994-03-30)	1-8, 10-17, 20-22, 25-27, 30,33, 38,40,42
A	column 3, line 32 - column 13, line 48	9,18,19, 24,28, 29,31, 32, 34-37, 39,41

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search: 14 July 1999

Date of mailing of the international search report: 20/07/1999

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Fax: (+31-70) 340-3016

Authorized officer
Maalismaa, J

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Intı ıonal Application No
PCT/US 99/07351

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0589576 A	30-03-1994	AU 658076 B	30-03-1995
		AU 4493793 A	17-03-1994
		CA 2099737 A	09-03-1994
		JP 6197156 A	15-07-1994
		US 5394540 A	28-02-1995